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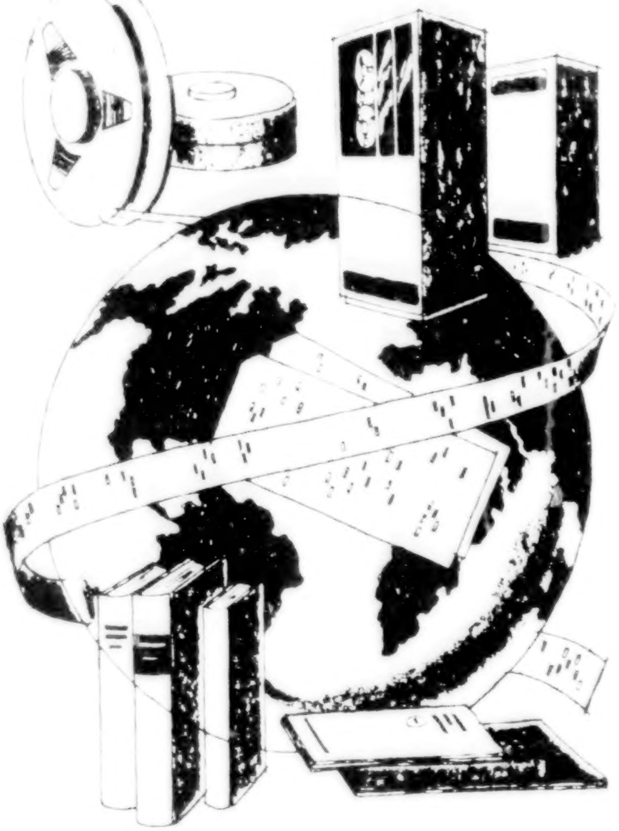

ORIGIN
41

SUMMARY OF AWARDS

FY 1981 and FY 1982

NATIONAL SCIENCE FOUNDATION
Directorate for Biological, Behavioral, and Social Sciences
Division of Information Science and Technology
Washington, D.C. 20550

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DEFINITIONS

The following definitions are essential to an understanding of this report:

- "Awards" refers to financial support given through a grant, contract, interagency agreement, or other arrangement, depending upon the nature of the work to be completed, the terms of performance, and the institution that performs the work.
- "Amendment" refers to an award which adds funds to an existing award with or without increasing the duration of NSF support.
- "Principal Investigator" refers to the scientist or administrator who is responsible for directing an NSF supported project.
- "Institution" refers to any organization which has accepted an award from NSF.

Awards excluded from this report are:

- Purchase Orders
- Personnel Services

The award data presented consist of program grants and contracts made from the Salaries and Expenses appropriations to the Foundation for Fiscal Years 1981-1982. Information contained in the report was obtained from program sources and may differ from official NSF records which may have different inclusions and exclusions.

INTRODUCTION

This report summarizes the awards made by the National Science Foundation in Fiscal Years 1981-1982 on recommendation by the Division of Information Science and Technology.

The report is divided into several sections. The first section lists the members of the Foundation's Advisory Committee for Information Science and Technology. The second section presents a summary table of awards and is arranged alphabetically by principal investigator. The third section, containing descriptions of the work funded, is arranged alphabetically by project title. The fourth section contains the subject index. The fifth section lists the reports received by the Division of Information Science and Technology as the result of work funded in previous years, and which have been deposited in the National Technical Information Service. Copies of these reports may be ordered from NTIS, 5285 Port Royal Road, Springfield, VA 22151.

Requests for additional information about specific projects should be addressed to principal investigators. General information on the current NSF information science research program and award procedures may be obtained from the Division of Information Science and Technology, National Science Foundation, Washington, D.C. 20550.

ADVISORY COMMITTEE FOR INFORMATION SCIENCE AND TECHNOLOGY

Mr. Joe B. Wyatt, *Chairman*
Vice President for Administration
Harvard University 617/495-4374
Cambridge, MA 02138 8/830-4374 (FTS)

Professor Elwyn R. Berlekamp
Departments of Mathematics, Electrical Engineering, and Computer Science
University of California
Berkeley, CA 94720
415/642-6919

Professor Joan W. Bresnan
Department of Linguistics and Philosophy
Massachusetts Institute of Technology
Cambridge, MA 02139
617/253-7545

Dr. Ruth M. Davis
President
The Pymatuning Group, Inc.
1625 I Street, NW
Suite 1017
Washington, D.C. 20006
202/296-3037

Professor Leonid Hurwicz
Department of Economics
University of Minnesota Graduate School
Minneapolis, MN 55455
612/373-4385

Dr. H. William Koch
Director
American Institute of Physics
335 East 45th Street
New York, NY 10017
212/661-9404

Professor R. Duncan Luce
Department of Psychology and Social Relations
Harvard University
William James Hall
33 Kirkland Street
Cambridge, MA 02138
617/495-3815
8/830-3815 (FTS)

Mr. Paul A. Strassmann
Vice President
Information Products Group
Xerox Corporation
Stamford, CT 06904
203/329-8711, x: 3102

Dr. Richard I. Tanaka
President
Systonetics
600 North Euclid Street
Anaheim, CA 92801
714/680-0910

PAST MEMBERS

Mr. Joseph Becker
Becker and Hayes, Inc.
2800 Olympic Boulevard
Suite 103
Santa Monica, CA 90404

Mr. Ben Russak
Crane Russak
3 East 44th Street
New York, NY 10017

FY 1981 AWARDS

DIVISION OF INFORMATION SCIENCE AND TECHNOLOGY

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Agnew, C. E.	Stanford Univ.	Innovation and Efficiency in Spectrum Management Theoretical Analysis	IST81-08350	$132,436	06/23/81 14	070
Allen, B. E.	U/Pennsylvania	Alternative Representations of Information in Microeconomic Systems	IST81-15734	125,959	08/03/81 24	003
Anderson, J. R.	Carnegie-Mellon Univ.	An Information Processing Analysis of Learning Geometry	IST80-15357	259,742	01/29/81 36	061
Anderson, J. A.	Brown Univ.	Cognitive Applications of Matrix Memory Models	BNS80-41376	31,500	01/12/81 12	015
Arbib, M. A. & McDonald, D. D.	U/Massachusetts	Dynamic Interaction of Multiple Representations: Vision and Language	IST81-04984	174,416	05/15/81 36	037
Ballard, B. W.	Duke Univ.	Natural Language Interfaces to "Layered" Domains: A Multi-Prototype Approach	MCS81-16607	62,598	07/15/81 24	088
Banerji, R. B.	Temple Univ.	Flexibility and Efficiency of Knowledge Representation in Intelligent Information Systems	MCS81-10104	79,298	07/30/81 24	048
Bookstein, A.	U/Chicago	Robustness Properties of the Bibliometric Laws	IST80-26564	23,810	02/03/81 12	112
Caporael, L. R.	Rensselaer Poly.	Attribution of Human Characteristics to Machine Intelligence	IST81-10625	34,785	06/19/81 12	008
Carter, G. C.	National Academy of Sciences	Partial Support of the Numerical Data Advisory Board (NDAB)	IST80-19605	15,139	03/17/81 12	096
Carter, G. C.	National Academy of Sciences	Partial Payment of Dues from the U.S. for the Committee on Data for Science and Technology of the International Council of Scientific Unions	IST81-12108	12,000	06/05/81 12	094
Charniak, E.	Brown Univ.	Research on Natural Language Processing (Frame Selection)	IST80-13690	131,920	01/26/81 24	110
Cooper, W. S.	U/California (Berkeley)	Nonstandard Decision Rules and Information Representations	IST81-13213	75,046	06/30/81 24	089
Corsi, J. R.	U/New Mexico	The Use of Teleconferencing in Administrative Hearings	IST81-12875	31,971	04/30/81 04	132
Dutton, W. H.	U/Southern California	Organizational Impact on Video-Teleconferencing: Pilot Study	IST80-23063	34,754	05/05/81 07	092

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Ellis, C. S.	U/Rochester	Concurrency in the Access and Manipulation of Information Structures	IST80-25761	67,381	10/21/80 24	029
Flowers, J. H.	U/Nebraska	Research on Human Information Processing of Visual Displays	IST81-10544	60,429	07/24/81 24	108
Friedman, J. R.	U/Michigan	Computational Studies of the Representation of Information in Logic and in Natural Language	IST81-05535	123,541	05/08/81 24	024
Gandy, O. H., Jr.	Howard Univ.	Tenth Annual Telecommunications Policy Research Conference	IST81-17704	17,000	08/07/81 14	123
Harris, V. B.	Oberlin College	Research on the Impact of a Computerized Circulation System on the Performance of a Large College Library	IST81-05308	7,500	03/12/81 24	111
Harris, Z. S.	Columbia Univ.	Information Correlates of Basic Language Structures	IST80-17043	115,471	12/16/80 0	058
Herrnstein, R. J.	Harvard Univ.	Studies on Natural and Artificial Visual Categories	IST81-00404	218,785	01/16/81 24	116
Holland, J. H.	U/Michigan	Research on Adaptive Knowledge Acquisition Systems	IST80-18043	118,437	12/30/80 24	106
Huber, G. P.	U/Wisconsin	A Study of the Distribution, Processing, and Use of Scientific and Technical Information in Research Organizations	IST81-13638	95,353	06/01/81 14	118
Hull, R. B.	U/Southern California	Theoretical Investigation of Database Constraints and Semantic Constructs	IST81-07480	28,949	06/18/81 24	127
Hurwicz, L.	U/Minnesota	Comparison and Analysis of Systems and Techniques of Economic Organizations	SES81-41494	55,999	06/25/81 12	017
Indow, T.	U/California (Irvine)	Geometrical Structure in Perceptual Systems	IST80-23893	90,075	04/10/81 24	051
Kantor, P. B.	Tantalus, Inc.	Study of the Cost Function for Academic Libraries	IST81-10510	99,957	09/01/81 24	117
Kaplan, S. J.	Stanford Univ.	Theory and Computation for Natural-Language Question-Answering	IST80-23889	50,209	03/16/81 24	128
Kaufman, H. G.	Polytechnic Inst.	Factors Related to Use of Scientific and Technical Information and Effectiveness of Engineers: A Longitudinal Study	IST181-10114	10,000	06/08/81 06	047

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Kemper, S.	U/Kansas	An Information Theoretic Approach to Reading	ISTI81-10438	76,989	07/20/81 24	067
King, D. W.	King Reseach	Systems Analysis of Scientific and Technical Communication in the United States	IST81-01862	8,009	01/09/81 0	121
King, D. W.	King Research	Statistical Indicators of Scientific and Technical Communication in the United States	ISTI81-01863	9,808	01/09/81 0	031
Klatt, D. H.	M.I.T.	Auditory Information Processing and Speech Perception	IST80-17599	142,000	03/20/81 18	009
Kolodner, J. L.	Georgia Institute	Computer Memory for Current Events	IST81-16892	132,664	09/02/81 24	028
Kraft, D. H.	Louisiana State University	Modelling of Generalizations of Boolean Query Processing in Retrieval Systems	IST81-15146	34,722	07/23/81 12	083
Liston, D. M.	King Research	Research into the Structure, Accessing, and Manipulation of Numeric Databases: Phase I	IST81-14042	29,970	09/25/81 06	105
Machlup, F.	New York Univ.	Knowledge: Its Creation, Distribution, and Economic Significance	IST80-16253	173,493	05/29/81 24	75
Mahoney, B.	Institute for Court Management	Evaluation of Telephone Conferencing to Conduct Civil Motion Hearings	IST80-24715	186,415	05/19/81 24	041
McAllister, P. R.	Computer Horizons	Interrelationships Between Federal Funding and Production of Scientific Papers	IST80-19032	95,163	04/14/81 12	071
Montgomery, C. A.	Logicon, Inc.	Workshop on Logic Programming for Intelligent Systems	IST81-13182	34,729	07/21/81 05	137
Morgan, M. G.	Carnegie-Mellon Univ.	Experimental Analysis of Factors in the Design of Information Systems for Modelling Engineering/Economic Decisions	IST81-12439	225,934	06/25/81 18	042
Payne, D. E.	U/North Dakota	Effects of Mass Media Interpersonal Contact and Social Background in a Rural Cross National Setting: A Longitudinal Study	IST81-04609	59,811	05/01/81 36	038
Pinker, S.	Stanford Univ.	The Mental Representation of 3-D Space	BNS81-14916	84,883	06/23/81 17	080
Richards, W. A.	M.I.T.	Natural Computation and Control	MCS81-09400	411,972	0327/81 12	085
Rissland, E. L.	U/Massachusetts	The Structure of Examples	IST80-17343	147,848	01/14/81 24	114
Robinson, J. J.	SRI International	Computational Efficiency of Formal Grammars	IST81-03550	169,826	08/06/81 24	023

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Rouse, W. B.	Georgia Institute of Technology	Modeling of Human Behavior in Seeking and Generating Information	IST81-19294	60,000	09/02/81 12	082
Sager, N.	New York Univ.	Computable Models of Time and Quantity in Natural Language Data	IST81-15669	184,451	09/14/81 24	019
Salton, G.	Cornell Univ.	Automatic Indexing and Clustered File Search Methodologies Applied to Business Correspondence	IST80-17589	147,435	01/07/81 24	011
Salton, G.	Cornell Univ.	Mathematical Models in Automatic Information Retrieval	IST81-08696	132,054	07/14/81 24	079
Saracevic, T.	Case Western Reserve Univ.	Classification and Structure of Questions in Information Retrieval	IST80-15335	101,782	01/23/81 12	013
Schank, R. C.	Yale Univ.	Theoretical Foundations of Natural Language Processing	IST81-06640	16,215	01/26/81 0	126
Schweickert, R. J.	Purdue Univ.	Analysis of Reaction Time Using Scheduling Theory	IST81-10535	66,686	06/12/81 24	005
Sciore, E.	SUNY/Stony Brook	Incorporating Structure and Semantics into Relational Databases	IST81-09824	53,821	06/17/81 24	056
Slotkin, H. W.	M.I.T.	Appraisal and Records Management Guidelines for Scientific and Technological Records	SES81-09479	60,000	08/07/81 24	006
Soloway, E. M.	Yale Univ.	Information Processing in Algebra and Computer Programming	IST81-14840	125,489	06/17/81 24	062
Tenebaum, A. M.	CUNY/ Brooklyn Col.	Efficiency of Sequential Search Algorithms	IST80-21350	84,646	03/11/81 24	039
Taylor, R. S.	Syracuse Univ.	Value Added Processes in the Information Life Cycle	IST81-06080	166,612	06/16/81 18	133
Warren, D. S.	SUNY/ Stony Brook	Representing Semantic Information Within Databases	IST81-04834	183,755	04/30/81 24	104
Weiner, S. B.	Center for Policy Research	Partial Support for a Workshop on Information Retrieval, November 18-20, 1980, Washington, D.C.	IST80-18904	6,538	11/20/80 05	095
Whinston, A. B.	Purdue Univ.	Development of a Computerized Decision Support System	IST81-08519	240,133	06/30/81 24	033
Wilensky, R.	U/California (Berkeley)	Modeling Contextual Language Understanding	IST80-07045	124,433	11/10/80 24	081
Winkler, R. L.	Indiana Univ.	Research on Information Aggregation and Value	IST80-18578	46,793	01/14/81 24	109

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Zadeh, L.A.	U/California (Berkeley)	Analysis of Imprecise Information	IST80-18196	195,825	11/24/80 36	004
Zadeh, L. A.	U/California (Berkeley)	A Theory of Approximate Reasoning	MCS80-41376	31,500	08/25/81 12	129

FY 1982 AWARDS

DIVISION OF INFORMATION SCIENCE AND TECHNOLOGY

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Allen, J. F.	Univ. of Rochester	Extended User-System Dialogues for Complex Information Retrieval	IST82-10564	$199,930	07/22/82 24	046
Amsler, R. A.	SRI International	Experimental Research on Knowledge Representations for Lexical Disambiguation of Full-Text Sources	IST82-08578	129,951	06/14/82 24	044
Anderson, J. A.	Brown Univ.	Cognitive Applications of Matrix Memory Models	BNS82-42090	32,612	03/22/82 12	014
Barwise, K. J.	Univ. of Wisconsin	Computational Aspects of Situation Semantics	MCS82-01940	52,609	06/03/82 24	021
Baumol, W. J.	Princeton Univ.	Productivity Growth and Scientific and Technical Information	IST82-00989	46,592	02/12/82 24	100
Biermann, A. W.	Duke Univ.	Voice Interactive Computer Systems	MCS82-13491	108,041	12/14/81	135
Blume, L. E.	Univ. of Mich.	The Demand for Information by Rational Agents and the Market for Information	IST81-20315	54,645	03/01/82 24	032
Brodie, M. L.	Univ. of Md.	Symposium of Conceptual Modelling: Perspectives from Artificial Intelligence, Databases and Programming Languages: May 26-28, 1982, College Park, MD	IST81-16809	40,339	02/02/82 12	119
Carter, G. C.	National Academy of Sciences	Partial Support of the Numerical Data Advisory Board	IST81-18882	130,169	11/17/81 12	097
Caulfield, H. H.	Aerodyne Research, Inc.	Synthetic Holographic Computer Output	IST82-60094	29,945	09/15/82 06	120
Cohen, K. C.	Continuous Learning Corporation	Adaptive Referencing—A New Approach to Design of the Interface Between an Access Sysem and Its User	IST82-60081	29,890	09/15/82 06	001
Croft, W. B.	Univ. of Mass.	A Framework for User-Oriented Adaptive Document Retrieval Systems	IST81-11108	121,240	12/11/81 24	049
Delaney, M. F.	Boston Univ.	Representation and Utilization of Non-Textual (Chemical Spectral) Information	IST81-20255	33,000	05/06/82 12	102
DeJong, G.	Univ. of Illinois	Explanatory Schema Acquisition	IST81-20254	116,855	12/11/81 12	045
Eastman, C. M.	Southern Methodist University	Performance of Multikey Information Search Algorithms	IST82-14611	17,644	07/22/82 12	098

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Elton, M. C.	New York Univ.	Behavioral Research on Broadcast Teletext	IST79-24889 A04	59,910	03/22/82 05	012
Ettema, J.	Univ. of Minn.	The Home Information Utility: Individual-Level Basis of Societal-Level Impact	IST82-12164	54,403	07/30/82 09	054
Falmagne, J.	New York Univ.	Assessment and Measurement of Knowledge—Theory and Algorithms	IST81-17057	193,839	10/16/81 30	007
Finin, T. W.	Univ. of Penn.	A Knowledge Based Approach to Intelligent Interactive Help Systems	IST81-20252	99,544	12/23/81 24	076
Granger, R. H.	Univ. of Calif.	Judgmental Inference in Understanding Textual Information	IST81-20285	64,158	06/16/82 12	074
Harris, S. E.	Georgia St. Univ.	Organizational Impacts of Local Information Network Technology	IST82-01445	47,119	03/30/82 06	093
Hegner, S. J.	Univ. of Vermont	Representation of Information and Ease of Update: A General Theory of Relational Data Base Normalization	IST82-12178	25,162	06/25/82 24	103
Hurwicz, L.	Univ. of Minn.	Comparison and Analysis of Systems and Techniques of Economic Organizations	SES82-18378	38,381	07/08/82 12	018
Jackendoff, R. Grimshaw, J.	Brandeis Univ.	Information Structure of a Natural Language Lexicon	IST81-20403	24,238	04/20/82 12	065
Jackendoff, R. Grimshaw, J.	Brandeis Univ.	Information Structure of a Natural Language Lexicon	IST82-13878 A01	20,809	07/12/82 0	066
Jensen, R. A.	Ohio St. Univ.	Informational Aspects of the Adoption and Diffusion of Innovation	IST82-08607	39,771	07/02/82 15	069
Jones, M. A.	SUNY/ Stony Brook	Inducing Lexical Definitions for Word-Based Parsers	IST82-08113	74,757	06/16/82 24	057
Jurs, P. C.	Penn. St. Univ.	Computer-Assisted Studies of Structure-Property Relationships	CHE82-02620	46,000	03/17/82 12	025
Kiesler, S. B.	Carnegie-Mellon Univ.	Computer-Mediated Communication	IST82-10701	149,923	08/05/82 24	027
Klatt, D. H.	Mass. Inst. of Tech.	Auditory Information Processing and Speech Perception	IST82-03373	132,500	02/02/82 18	009
Knuth, D. E.	Stanford Univ.	Theoretical Basis for the Development of Document Preparation Systems	IST82-01926	153,961	06/03/82 12	125

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Kooi, R.	Relational Tech., Inc.	Managing Text as Data	IST82-60519	29,876	09/21/82 06	078
Kraemer, K. L.	Univ. of Calif., Irvine	Longitudinal Study of Computer Technology and Impact in Cities	SES81-15547	185,572	03/25/82 24	077
Kraft, D. H.	Louisiana State Univ.	Group Travel to the Fifth International Information Retrieval Conference: West Berlin, May 1982	IST81-22027	10,000	04/20/82 06	052
Langlois, R. N.	New York Univ.	Information Science and Economic Theory	IST81-10537	38,609	11/27/81 12	064
Machlup, F.	New York Univ.	Information Science: An Analysis of Methological Issues and Interdisciplinary Relationships	IST82-10903	18,820	04/14/82 09	063
Marcus, R. S.	Mass. Inst. of Tech.	Investigation of Models for Enhanced Information Retrieval Through Computer-Mediated Assistance	IST82-01842	97,445	02/05/82 12	073
Milgrom, P.	Northwestern Univ.	On the Role of Information in a Productive Organization	IST82-08600	38,822	06/29/82 24	090
Morgan, M. G.	Carnegie-Mellon Univ.	Experimental Analysis of Factors in the Design of Information Sysems for Modelling Engineering/ Economic Decisions	IST82-07325	8,723	04/01/82 0	043
Niehoff, R. T.	Battelle Columbus	The Impact of Subject Switching—An Assessment	IST81-11497	144,000	01/26/82 16	055
Noam, E. M.	Columbia Univ.	Technical Innovation in Established Cable Television Systems in Comparison with Developments in the State-of-the-Art	IST82-09485	9,978	06/10/82 09	122
Olson, M. H.	New York Univ.	Pilot Testing of Distributed Work Environment Organization and Technology	IST82-08451	18,648	06/04/82 03	099
Parsons, C. D.	Columbia Univ.	Text Constructed from Informational Units	IST81-14421	265,986	12/11/81 20	124
Pearl, J. Dalkey, N.	Univ. of Calif.	Studies in the Organization of Information Structures	IST82-01556	36,898	03/04/82 18	115
Pearl, J.	Univ. of Calif.	Research on Computer-Based Systems for Problem Structuring	IST81-19045	77,806	11/05/81 12	107
Perry, J. R.	Stanford Univ.	Computational Aspects of Situation Semantics	MCS82-11902	69,263	06/02/82 24	022

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Pool, I. D.	Mass. Inst. of Tech.	A Workshop on Measurement of Communications and Information (Information Science), Summer of 1982, Cambridge, MA	IST82-07403	29,326	04/23/82 03	138
Reichman, R.	Univ. of Calif.	Discourse Models for Extended Person—Computer Interaction	IST81-20018	92,840	12/21/81 24	035
Reintjes, J. F.	Mass. Inst. of Tech.	Advanced Technologies for Electronic Transfer of Text and Graphics	IST81-22080	149,545	07/23/82 24	002
Richards, W. A.	Mass. Inst. of Tech.	Natural Computation and Control	MCS82-41840	445,716	07/29/82 12	086
Rissland, E. W.	Univ. of Mass.	Conference on Intelligent User Interfaces: October 19-22, 1982; Woodstock, Vermont	IST82-12236	28,818	07/20/82 12	030
Ritchie, R. W.	Univ. of Wash.	Toward Automated Natural Language Processing: Phrase Linking Grammars for Syntax and Semantics	IST81-18393	101,184	04/30/82 12	130
Rodman, R.D.	NC St. Univ.	Voice Interactive Computer Systems	MCS81-13494	33,243	12/14/81 12	136
Saari, D. G.	Northwestern Univ.	Information Theory of Equilibrium Processes and of Regulatory Systems	IST81-11122	46,592	02/12/82 24	068
Sager, N.	New York Univ.	Computable Models of Time and Quantity in Natural Language Data	IST82-03374	110,818	12/11/81 0	020
Salveter, S. C.	Boston Univ.	Verbs in Databases	IST82-14622	129,980	01/17/82 24	134
Sappington, D.	Univ. of Penn.	Optimal Incentive Schemes Under Asymmetric Information	IST82-15300	25,655	07/22/82 12	091
Schank, R. R.	Yale Univ.	Information Models for Reconstructive Memory Memory and Learning	IST81-20451	80,950	02/16/82 12	059
Schmidt, C.	Rutgers Univ.	Information Processing Analysis of Human Understanding of Action Sequences and Computational Traces	IST81-19889	91,885	04/20/82 12	060
Shapiro, C.	Princeton Univ.	Signals of Product Quality	SES82-07377	20,833	06/15/82 24	113
Simmons, R. F.	Univ. of Texas	Query Logic for a Text-Knowledge Base	IST82-00976	25,162	04/26/82 24	101
Small, S. L.	Univ. of Rochester	Distributed Information Processing Models of Language Interpretation	IST82-08571	113,606	07/22/82 24	036

Principal Investigator(s)	Institution	Title	Award No.	Amount	Award Date/ Duration (Month)	Summary No.
Smith, L. C.	Univ. of Rochester	Development of a Taxonomy of Representations in Information Retrieval System Design	IST82-08576	29,960	07/15/82 12	034
Spatt, C.	Carnegie-Mellon Universiy	Models of Information in Industrial Organization	IST81-20252	25,000	07/21/82 24	084
Terleckyj, N.	National Planning Association	Growth of the Communication Sector and Productivity of the American Economy	IST81-19070	53,707	11/06/81 12	053
Ullman, S. Vaina, L.	Mass. Inst. of Tech.	A Functional Representation of Visual Information	IST81-16549	151,183	04/01/82 26	050
Walker, D. E.	SRI International	Natural Language Access to Text	IST82-09346	88,032	08/19/82 12	087
Waltz, D. L.	Univ. of Illinois	Understanding Natural Language Scene and Event Descriptions: Cognitive Universals and Computer Programs Based on Combined AI and Linguistics Methodologies	IST81-17238	267,407	10/23/81 36	131
Wang, G. Y.	Transtech International Corporation	Computer Input and Output of Chinese Programs	IST82-60251	30,000	09/15/82 06	026
Wilde, L. Schwartz, A.	Calif. Inst. of Tech.	Intervening in Markets on the Basis of Imperfect Information: An Information Theoretic Approach	SES81-17708	98,980	01/13/82 24	072
Wilensky, R.	Univ. of Calif.	Evaluating a Knowledge Representation for Planning and Natural Language Understanding	IST82-08602	73,184	06/29/82 12	040
Williams, M. E.	Univ. of Illinois	Comparative Analyses of Online Retrieval Interfaces	IST82-09704	250,003	07/22/82 30	016

SUMMARIES OF AWARDS
FISCAL YEARS 1981 AND 1982

#001

Adaptive Referencing—a New Approach to Design of the Interface Between an Access System and Its User. *Continuous Learning Corporation,* 151 Erie Street, Cambridge, MA 02139. K. C. Cohen. $29,890 for 6 months beginning September 15, 1982.

This project addresses the problem of enabling end users to find information relevant to their current problems while insuring that they do not miss important and germane information easily overlooked with traditional information access systems. A potential solution to this problem, called the Adaptive Reference System (ARS), has been developed at MIT. Using an intent-structured thesaurus, the prototype seeks interactively to locate a user's problem at a single concept, rather than to identify a set of concepts that seem applicable to the user's inquiry.

The project's objectives are to refine the MIT prototype and to access its commercial potential. The prototype system covers the topic of energy conservation. A refined version will be tested in the laboratory and in the field with existing publicly accessible databases. Data will be collected on the costs of using an ARS and on the value of such use in solving constructed and free-choice problems. Similar data will be collected for the same problems and databases without benefit of an ARS. The results of this research will be applicable to the development of ARS in a variety of knowledge domains.

#002

Advanced Technologies for Electronic Transfer of Text and Graphics. *Massachusetts Institute of Technology,* Department of Electrical Eng., & Computer Science, Cambridge, MA 02139. J. F. Reintjes. $149,545 for 24 months beginning July 23, 1982.

The goal of the proposed project is to investigate how advanced technologies can be employed to transfer, electronically, broad classes of information stored in a variety of media. Information stored as bound reports and volumes, on single sheets of paper of all sizes, on microfilm and in massive archival storage media such as optical disks will be considered. Emphasis will be placed on newly emerging technologies that show promise of yielding high-quality reliable systems at reasonable costs. Specific investigations include system studies, solid-state digital scanners and applications of data-compression technology.

The proposed work is based on a previous Foundation supported project (NSF Grant IST-7823251). It is partially related to the application of advanced technology for transferring electronically textual and graphic information.

#003

Alternative Representations of Information in Microeconomic Systems. *University of Pennsylvania,* Department of Economics, Philadelphia, PA 19104. B. E. Allen. $125,959 for 24 months beginning August 3, 1981.

This research will examine some aspects of the role of information in microeconomic theory. Three major issues will be addressed: expectation formation based on available information, a structure for information, and the existence of rational expectations equilibria.

This research will contribute to the development of mathematical models of how economic agents form expectations based on information available to them. It also will use mathematical techniques to study a range of problems in economies under uncertainty. Finally, this research continues previous work by the Principal Investigator on the existence of rational expectations equilibria.

#004

Analysis of Imprecise Information. *University of California,* Electronic Research Laboratory, Berkeley, CA 94720. L. A. Zadeh. $195,825 for 36 months beginning November 24, 1980.

This research is aimed at the development of a conceptual framework for dealing with soft information, that is, with imprecise information in which the sources of uncertainty are partly probabilistic and partly possibilistic in nature. Although much of the information on which real-world decisions are based is soft, according to the foregoing definition, the conventional approaches to information analysis do not address this issue. This is true largely because the techniques provided by probability theory are not intended for dealing with the possibility distribution or with probabilistics described in linguistic terms such as likely, not very likely, highly unlikely, etc. Techniques for dealing with soft information will have useful applications in the design of expert systems, information retrieval systems, diagnostic systems, decision support systems, large-scale systems analysis and, more generally, in dealing with databases in which the resident information is incomplete, imprecise or unreliable.

In order to deal with such information, concepts drawn from both probability theory and possibility theory will be employed to extend the translation rules in the recently developed measuring—representation language PRUF—a language in which the concept of a possibility distribution plays a central role. Applications to the analysis of exert systems, credibility assessment, model validation and system identification will be explored.

#005

Analysis of Reaction Times Using Scheduling Theory. *Purdue University*, Department of Psychological Sciences, West Lafayette, IN 47907. R. J. Schweickert. $66,686 for 24 months beginning June 12, 1981.

Partially concurrent human mental processes are the subject of this research. When a set of mental processes, such as perceiving and deciding, must be executed to perform a task, the brain must resolve a problem analogous to that faced by a computer operating system, namely, how to allocate processing capability to the various subactivities, given that some may have to be completed before certain others can begin, while in some cases concurrent processing is possible.

In order to study these processes the investigator brings together the critical path method from scheduling theory with the methodology of reaction time research. The primary technique for analyzing reaction times, the additive factor method, is appropriate for sequential rather than concurrent processing, but it combines with the critical path method to produce a more appropriate formalism. Because the actual individual processes under study cannot be observed directly, reaction times are used to determine how they are organized and how much time is allotted to each.

The specific task under investigation is a dual task of digit and tone identification, with variable delay in the onset of the second signal. Deterministic methods, studied analytically, are compared to stochastic simulations. Since the scheduling networks constructed using the method are not necessarily unique, the study includes an attempt to characterize the set of all networks which can represent a given set of reaction times.

#006

Appraisal and Records Management Guidelines for Scientific and Technological Records. *Massachusetts Institute of Technology*, Department of Special Collections, Cambridge MA 02139. H. W. Slotkin. $60,000 for 24 months beginning August 7, 1981.

The complexity and volume of scientific records, the lack of appraisal guidelines for them, and the failure of traditional archival appraisal theory to deal with scientific data have discouraged archivists committed to the preservation of scientific and technological documentation. The development of appraisal and retention guidelines applicable to scientific records in a variety of settings will help archivists to select permanently valuable records from the immense volume of scientific documentation.

To establish appraisal criteria for scientific and technological records, this project will examine collections in M.I.T. Archives and on site at specific laboratories; discuss records with creators and users, and sociologists of science to examine the scientific process and the creation and use of records; examine the process by which appraisal guidelines should be formulated, tested, and used; formulate specific guidelines and attempt to have them tested; and make recommendations about future work and appraisal strategies.

#007

Assessment and Measurement of Knowledge—Theory and Algorithms. *New York University*, Department of Psychology, New York, NY 10006. J. Falmagne. $193,839 for 30 months beginning October 16, 1981.

The objective of this research is a general methodology for the assessment and measurement of the knowledge of either a person or a programmed computer, with respect to a specific body of information. The project includes the development of both a theoretical framework and practical algorithms. The results of assessments are to provide the basis for complex decisions by computer. It is intended that the approach ultimately provide a precise language in which, on one hand, opinions, theories and controversies about knowledge can be translated and analyzed, and, on the other hand, efficient procedures dealing with matters of knowledge can be formulated. Part of the research involves clarifying its own limitations: constraints will be set on how a body of information must be structured in order for this methodology to be applicable. Applications on these developments include: (i) alternative to standard psychometric tests, in which assessments of knowledge replaces evaluation as a primary goal; (ii) the construction of sophisticated monitoring devices for computer-assisted courses; and (iii) the design of instruments for comparing states of knowledge.

#008

Attribution of Human Characteristics to Machine Intelligence. *Rensselaer Polytechnic Institute*, Human Dimension

Center, Troy, NY 12181. L. R. Caporael. $34,785 for 12 months beginning June 19, 1981.

This research is designed to gain a better understanding of the social and psychological processes related to the attribution of human characteristics to machine intelligence (anthropomorphism). The objectives of the research are to identify the attributes of human-machine interaction, develop a model that integrates views of the scientific and conventional (lay) communities on human—anthropomorphic processes.

#009

Auditory Information Processing and Speech Perception. *Massachusetts Institute of Technology*, 77 Massachusetts Avenue, Cambridge, MA 02139. D. H. Klatt. $132,500 for 18 months beginning February 2, 1982.

The objective of this research is to provide an information-theoretic model of speech perception based on human auditory processes. Speech production involves encoding the complexity of components which comprise human verbal articulations into an acoustic waveform. Speech perception, on the other hand, consists of decoding the information contained in the waveform to recover the lexical, syntactic and semantic properties of the intended message. Current models of speech perception are either not specified with detail sufficient to determine whether proposed solutions will work, or there is good reason to doubt the ability of a model to handle certain of the problems.

This research will investigate aspects of cognitive information (as encoded in speech) processing specific to human auditory pattern recognition. It will endeavor to spell out in detail the nature of the encoding of linguistic information in speech waveforms, indicate why decoding is inherently difficult, describe and evaluate a decoding algorithm by hypothesizing words from acoustic data, demonstrate ways in which the algorithm is theoretically superior to a number of alternative models in an information-theoretic sense, and determine whether various portions of the model are consistent with perceptual data.

#010

Auditory Information Processing and Speech Perception. *Massachusetts Institute of Technology*, Research Laboratory of Electronics, Cambridge, MA 02139. D. H. Klatt. $142,000 for 18 months beginning March 20, 1981.

The objective of this research is to provide an information-theoretic model of speech perception based on human auditory processes. Speech production involves encoding the complexity of components which comprise human verbal articulations into an acoustic waveform. Speech perception, on the other hand, consists of decoding the information contained in the waveform to recover the lexical, syntactic and semantic properties of the intended message. Current models of speech perception are either not specified with detail sufficient to determine whether proposed solutions will work, or there is good reason to doubt the ability of a model to handle certain of the problems.

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#011

Automatic Indexing and Clustered File Search Methodologies Applied to Business Correspondence. *Cornell University*, Department of Computer Science, Ithaca, NY 14853. G. Salton. $147,435 for 24 months beginning July 7, 1981.

The primary objective of this research is to advance the theory of automatic document indexing. The purpose is to enable the construction of algorithms for automated indexing of documents which are characterized by brevity of form but not necessarily of content. For example, position papers prepared for high level decision-makers are usually brief but extremely high in content. Traditional indexing techniques have focused on larger documents such as books where the redundancy factor produces a large array of frequently used terms so that it is possible to utilize statistical algorithms to determine the main theme. Brief documents, on the other hand, may identify several significant topics but may not mention them more than once or twice. The underlying issues involved are of fundamental interest to information science.

Business correspondence is representative of the class of documents to which this research is addressed. But in addition they constitute an important component of office automation. Thus, the project also has a significant applied research objective.

#012

Behavioral Research on Broadcast Teletext. *New York University*, Alternate Media Center, 725 Broadway, New York, NY 10003. M. C. Elton. $59,910 for 5 months beginning March 22, 1982.

This award is a supplement to Grant No. IST79-24889. The project is a test of behavioral impacts of a "teletext" information retrieval system which uses a portion of the television broadcast signal to provide access to a text and graphic base to residential television viewers. The research examines human, economic and organizational factors as they affect the use and usefulness of the innovation. Research supported by this award includes laboratory experimentation on human perception of textual information via television, surveys of usage of teletext and other media and analysis of actual use of a teletext system by an experimental sample. Support for the technical components and the operations of the experimental system is provided by the Corporation for Public Broadcasting and local information service industries.

#013

Classification and Structure of Questions in Information Retrieval. *Case Western Reserve University*, School of Library Science, Cleveland, OH 44106. T. Saracevic. $101,782 for 12 months beginning January 23, 1981.

The primary objective of this research is to gain a beter understanding of the classification and structure of questions. Question analysis is important to information retrieval since it helps users to formulate their questions so they are compatible with and understandable by the information system with which they are interacting.

To accomplish their objectives the researchers will develop a model that reflects the elements and processes associated with question asking in information retrieval, formulate a set of attributes suitable as a basis for classification of questions and develop a scheme for classification of questions, develop associated measures and procedures for categorization of questions into various types and associated structures, and develop a standardized protocol for capturing questions in information retrieval so they will be suitable for classification and structural, lexical and contextual analyses.

#014

Cognitive Applications of Matrix Memory Models. *Brown University*, Department of Psychology and Center for Neural Sciences, Providence, RI 02912. J. A. Anderson. $32,612 for 12 months beginning March 22, 1982.

A model for memory based on ideas from neuroscience has been developed and published previously. It is assumed that (a) nervous system activity is most usefully represented as a set of stimultaneous individual neuron activities in a group of neurons (a state vector) and (b) changes in synaptic strength of a particular (correlational) kind store memeory, forming a matrix of synaptic connectivities which can couple associated state vectors. Recent extensions of this model involved positive feedback of a set of neurons on itself and introduction of a simple limiting non-linearity. This work will develop this model further. Such models seems to be very useful for describing human perceptual processes quite close to the sensory input. Non-linear extensions, to be investigated, seem to be able to make significant contact with questions of more cognitive relevance such as categorization, logical inference, and semantic networks. Such models may have considerable practical use since they are able to generalize, associate and categorize, yet are immune to certain pathologies of large systems: that is, since there are a fixed number of modifiable synapses operating in parallel, there is little possibility of the kinds of exponential retrieval and storage disasters that haunt data bases of very large size.

#015

Cognitive Applications of Matrix Memory Models. *Brown University*, Department of Psychology, Providence, RI 02912. J. A. Anderson. $31,500 for 12 months beginning January 12, 1981.

A model for memory based on ideas from neuroscience has been developed and published previously. It is assumed that (a) nervous system activity is most usefully represented as a set of stimultaneous individual neuron activities in a group of neurons (a state vector) and (b) changes in synaptic strength of a particular (correlational) kind store memory, forming a matrix of synaptic connectivities which can couple associated state vectors. Recent extensions of this model involved positive feedback of a set of neurons on itself and introduction of a simple limiting non-linearity. This work will develop this model further. Such models seem to be very useful for describing human perceptual processes quite close to the sensory input. Non-linear extensions, to be investigated, seem to be able to make significant contact with questions of more cognitive relevance such as categorization, logical inference, and semantic networks. Such models may have considerable practical use since they are able to generalize, associate and categorize, yet are immune to certain pathologies of large systems: that is, since there are a fixed number of modifiable synapses operating in parallel, there is little possibility of the kinds of exponential retrieval and storage disasters that haunt data bases of very large size.

#016

Comparative Analyses of Online Retrieval Interfaces. *University of Illinois*, Coordinated Science Laboratory, 809 S. Wright Street, Champaign, IL 61820. M. E. Williams. $250,003 for 30 months beginning July 22, 1982.

This research project is a semi-controlled experiment which will allow a systematic comparison of end-users of three retrieval system interfaces: command Boolean, prompted Boolean, and associative retrieval. Patterns of user interaction with each system and the outcome in terms of retrieval system performance and user satisfaction will be examined.

The study will provide important data on user behavior and satisfaction with different system designs and be applied to future information system for non-specialists.

#017

Comparison and Analysis of Systems and Techniques of Economic Organizations. *University of Minnesota,* Department of Economics, Minneapolis, MN 55455. L. Hurwicz. $55,999 for 12 months beginning June 25, 1981.

This research develops techniques of analysis that can be used to improve the understanding of existing economic organizational structures and establishes foundations for the design of economic mechanisms that would be efficient and also satisfy other social desiderata. The primary focus is on the possibilities and limitations of designing decentralized economic mechanisms. The structure of such mechanisms is examined from two points of view: information processing and incentive aspects. While much remains to be done in each of these two directions, the main gap in present knowledge is in the area of their interaction; this is becoming the central thrust of proposed research.

In particular, where optimal Nash equilibria can be produced at the expense of considerable enlargement of message spaces, it is proposed to investigate the extent to which smaller message spaces can be used without loss of optimality at equilibrium.

In contrast to much recent work, the "manipulative" (rather than "naive") Nash equilibria, and production rather than pure exchange decisions are examined intensively.

An effort is made further to develop techniques of deductive construction (e.g., by integrability techniques) of mechanisms satisfying the given desiderata, rather than to help for a discovery of such mechanisms by a haphazard search procedure.

#018

Comparison and Analysis of Systems and Techniques of Economic Organizations. *University of Minnesota,* Department of Ecnomics, Minnesota, Department of Economics, Minneapolis, MN 55455. L. Hurwicz. $38,381 for 12 months beginning July 8, 1982.

This project continues the development of a theory of resource allocation mechanisms. In the traditional approaches the resource allocation mechanisms was considered as given, e.g., perfect competition, oligopoly, etc., and the question was whether it has certain optimality properties, e.g., Pareto-optimality or the maximization of a social welfare function. The investigator is largely responsible for the approach that treats the problem as one of finding a mechanism that satisfies a given set of constraints and desiderata. In this project information processing is emphasized. Both continuum message spaces (studied by the techniques of differential geometry and topology) and discrete message spaces (where problems tend to be of a combinatorial nature) are analyzed. The special informational features of infinite horizon economies are also derived. Techniques of game theory are used to study the design of incentive structures.

#019

Computable Models of Time and Quantity in Natural Language Data. *New York University,* Linguistic String Project, New York, NY 10012. N. Sager. $184,451 for 24 months beginning September 14, 1981.

The objective of this project is to develop formal representations of both temporal and quantitative information from text files as a basis for developing algorithms for question-answering in these domains. The research will make use of an existing system for the computer processing of natural language texts developed by the principal investigator and her associates. The new programs will make natural language information manageable by computer in a manner similar to the way database management systems are now used to manage files of numerical and tabular data.

The investigation will use insights from artificial intelligence research and database management techniques in considering time and quantity, which do not have regular relationships to structures in language. The validity of the represenations will be tested by implementing them within text-based databases, where the ability to retrieve and process subject-specific information depends on calculations of the general information (time order, quantity relations). A test of the efficacy of the representation will be the ability of the system to return correct responses to complex queries involving time and/or quantity relations.

#020

Computable Models of Time and Quantity in Natural Language Data. *New York University,* Linguistic String Project, 251 Mercer Street, New York, NY 10012. N. Sager. $100,818 for 00 months beginning December 11, 1981.

The objective of this project is to develop formal representations of both temporal and quantitative information from text files as a basis for developing algorithms for question-answering in these

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domains. The research will make use of an existing system for the computer processing of natural language texts developed by the principal investigator and her associates. The new programs will make natural language information manageable by computer in a manner similar to the way database management systems are now used to manage files of numerical and tabular data.

The investigation will use insights from artificial intelligence research and database management techniques in considering time and quantity, which do not have regular relationships to structures in language. The validity of the representations will be tested by implementing them within text-based databases, where the ability to retrieve and process subject-specific information depends on calculations of the general information (time order, quantity relations). A test of the efficacy of the representation will be the ability of the system to return correct responses to complex queries involving time and/or quantity relations.

#021

Computational Aspects of Situation Semantics. *University of Wisconsin,* Department of Computer Sciences, Madison, WI 53706. K. J. Barwise. $52,609 for 24 months beginning June 3, 1982.

Situation semantics is a mathematical theory of linguistic meaning that grew out of artificial intelligence work in natural language processing. The goals of research in situation semantics include developing computationally feasible procedures for natural language understanding the systems, developing the mathematical theory of situation semantics, and comparing the efficiency of situation semantics to more standard approaches to the theory of linguistic meaning. This same research is being funded under MCS-8211902 to support Professor Barwise's colleague and coworker, Professor Perry, at Stanford University.

#022

Computation Aspects of Situation Semantics. *Stanford University,* Department of Computer Sciences, Stanford, CA 94305. J. R. Perry. $69,263 for 24 months beginning June 2, 1982.

Situation semantics is a mathematical theory of linguistic meaning that grew out of artificial intelligence work in natural language processing. The goals of research in situation semantics include developing computationally feasible procedures for natural language understanding systems, developing the mathematical theory of situation semantics, and comparing the efficiency of situation semantics to more standard approaches to the theory of linguistic meaning. This same research is being funded under MCS-8201940 to support Professor Perry's colleague and coworker, Professor Barwise, at the University of Wisconsin-Madison.

#023

Computational Efficiency of Formal Grammars. *SRI International,* Artificial Intelligence Center, Menlo Park, CA 94025. J. J. Robinson. $169,826 for 24 months beginning August 6, 1981.

The subject of the investigation is the computational efficiency of formal grammars which is important to the development of information processing systems. More specifically it addresses the computational efficiency that potentially arises from the use of a particular grammatical formalism called the metarule. A metarule is an operation that can transform rules of a phrase structure grammar into additional rules, thereby creating what is known as an augmented phrase structure grammar (APSG). The metarules constitute a representation of the syntactic and semantic generalizations holding across individual rules.

The major question addressed is whether metarules can lead to simultaneous achievement of the dual objectives of (i) capturing significant linguistic generalizations and (ii) providing the basis for correct and computationally efficient procedures for determining the syntactic structure and semantiac interpretation of input sentences. A concomitant question is whether some generalizations expressable by metarules are handled more efficiently by modifying the parasing process than by deriving new rules. An additional research product is the development of a computational system in which to explore linguistic hypotheses about the grammar of a particular language or about the processing properties of grammatical representations.

More specific questions addressed in this work concern the number of rules produced by various metarules, the number and kinds of ambiguities appearing when sentences are parsed, the difficulty of constraining incorrect interpretations, and running time and storage requirements of the parsing process using the derived rules. Existing computational resources for defining and applying metarules and resulting APSGs will be adapted and utilized in addressing these issues.

#024

Computational Studies of the Representation of Information in Logic and in Natural Lanaguage. *University of Michigan,* Department of Computer and Communication Science, Ann Arbor, MI 48109. J. B. Friedman. $123,541 for 24 months beginning May 8, 1981.

This research will continue and broaden current study of logic-based formal systems for natural

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language, using the computer as a research tool. Formal linguistic theories can explicate and clarify the relationships among information, semantic theory, and the grammatical structure of language. Computer implementation imposes a processing view which can enhance the theory in a manner consistent with the constraints imposed by the realities of the communication process. The primary basis for the studies is a system of representation known as Montague grammar, a well-defined theory in which important questions can be phrased precisely and answers can be formulated and tested. It has now led to the introduction of a number of variants that expand its application to natural language.

The main goals of the proposed research are (1) to investigate generalizations and variants of Montague grammar in an investigation of the possibilities of producing English sentences from logical formulas, (3) to develop more formally the notions of dynamic partial models and dynamic interpretations, relating them to other similar ideas arising in artificial intelligence, and (4) to investigate possible implications and applications of computational work on Montague grammar in the modeling of cognitive processes and in data base theory.

#025

Computer Assisted Studies of Structure-Property Relationships. *Pennsylvania State University*, 207 Old Main, University Park, PA 16802. P. C. Jurs. $46,000 for 12 months beginning March 17, 1982.

This research effort deals with computer-assisted studies of relationships between chemical structure and physical properties of organic compounds. The work will be carried out with the ADAPT computer software system which has been designed and implemented over the past five years to provide the user with a wide variety of capabilities applicable to structure-activity studies. ADAPT performs the following mutually-supportive tasks: input, storage, and management of sets of molecular structures; generation of three-dimensional molecular models; development of molecular structure descriptors of a variety of types; and application of statistical and pattern recognition methods of analysis develop correlations portion of the research will consist of improving and expanding the ADAPT system largely with better descriptor development routines. The major portion of the research will focus on the application of the computer-based methodology to interesting chemical problems, principally the development of mathematical models for the prediction of carbon-13 nuclear magnetic resonance chemical shifts from the structures of heteroatom-containing organic compounds.

#026

Computer Input and Output of Chinese Programs. *Transtech International Corporation*, 31 Washington Street, Wellesley, MA 02181. G. Y. Wang. $30,000 for 6 months beginning September 15, 1982.

This project addresses the problems of identifying Chinese characters to a computer system on input and representing their ideographic patterns on output. Preliminary analysis indicates four main approaches to the input problem: large keyboard, phonetical coding, numerical coding, and the word-root approach. SINOTERM, a variant of the word-root approach, offers a practical means of typing Chinese with no more than 128 keys. Output has been effected by mechanical type, by photographic fonts, by digitized optical techniques, and by dot-matrix fonts. This last approach offers the greatest flexibility where mass storage can be used for the fonts and accessed rapidly under computer control without used of an optical system. The project will evaluate existing input and output methods to identify the optimum combination for mechanization by microcomputer-controlled devices.

The results will be applicable in the design of a system for computer input and output of Chinese characters.

#027

Computer-Mediated Communication. *Carnegie-Mellon University*, Department of Social Sciences, 5000 Forbes Avenue, Pittsburgh, PA 15213. S. B. Kiesler. $149,923 for 24 months beginning August 5, 1982.

This is a program of research on the effectiveness and application of computer-mediated communications for industrial and business organizations. The technologies studied are synchronous and asynchronous message systems. These technologies are viewed as organizational resources, which in turn, comprise a major input to organizational communication. Based upon recent research in social cognition and group behavior, hypotheses are tested pertaining to the systematic effects of behavior of computerized communication. These outcomes include changes in the style, efficiency and effectiveness of nonroutine exchange of information, and group decision making. Several experiments are proposed to estimate the role of computer-mediated communication in such phenomena as disinhibition, polarization of opinion, "groupthink," and selective attention to (or interpretations of) data. For testing predictions and estimating effects, the researach employs adaptions of factorial designs and experimental tasks used in previous research on groups.

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#028

Computer Memory for Current Events. *Georgia Institute of Technology*, Department of Information and Computer Science, Atlanta, GA 30332. J. L. Kolodner. $132,664 for 24 months beginning September 2, 1981.

Organization and retrieval of current event information in a large, diverse, long-term memory is the general topic under study in this project. The problems associated with such retrieval have been deliberately bypassed in existing natural language understanding systems, since, as a matter of research strategy, whatever knowledge structures were needed for understanding have been made readily available to the processor, thereby allowing emphasis to be placed on the use, rather than the retrieval, of these structures.

Particular attention is paid here to the processes necessary to maintain good organization as new events are added to the memory. It is also desirable to reorganize the memory in response to needs of users, as inferred from use of the system. The structures to be accessed here are more complex than in typical retrieval systems, so an important part of the project is devising retrieval systems, so an important part of the project is devising retrieval strategies appropriate for these structures. Progress on these tasks will contribute to the design of "intelligent" information retrieval systems.

#029

Concurrency in the Access and Manipulation of Information Structures. *University of Rochester*, Computer Science Department, Rochester, NY 14627. C. S. Ellis. $67,381 for 24 months beginning October 21, 1980.

One of the objectives of data base design is to collect the information needed for various related applications and organize it into a unified system that allows efficient access and modification. With many users sharing the data structures of a large data base, purely sequential operations may provide less than satisfactory performance.

Concurrent operations, in contrast, potentially improve performance but introduce new problems (e.g., indefinite postponement) and aggravate old ones (e.g., consisency). Thus an important area of investigation deals with techniques for increasing concurrency of operations (primarily search, insertion, and deletion) on the kinds of data structures employed in data base systems.

In sequential programming "good" solutions are often based on recognized techniques or data structures. For parallel processing, more work is needed to build up a repertoire of techniques and data structures, to evaluate their performance, and to develop guidelines for their use. This background motivates the following proposed lines of research: (1) to identify and add to the set of techniques for *concurrent* manipulation of structured data, (2) to characterize the correctness issues associated with the application of these techniques, (3) to suggest a set of relevant performance measures, and (4) to provide a simulation tool for company solutions.

This project was originally funded as NSF Grant IST 80-12441 to the University of Oregon, and was transferred to the University of Rochester when the investigator accepted a faculty position there.

#030

Conference on Intelligent User Interfaces: October 19-22, 192, Woodstock, Vermont. *University of Massachusetts*, Department of Computer and Information Science, Amherst, MA 01003. E. W. Rissland. $28,818 for 12 months beginning July 30, 1982.

Intelligent Users Interfaces (IUIs) are systems which mediate between humans and information systems. They provide assistance in matters of computer expertise and interpret enough of the user's knowledge base and the systems information base to act as an intelligent assistant. The conference will result in a published proceedings and a report which will include: (1) a summary of the state of the art, (2) a discussion of current major research issues, and (3) recommendations for further research.

#031

Statistical Indicators of Scientific and Technical Communication in the United States. *King Research*, Rockville, MD 20852. D. W. King. $9,808 for 0 months beginning January 9, 1981.

This is the third year of a continuing effort to develop statistical indicators of scientific and technical communication. This third-year effort will result in the development of the first detailed model that will allow us to trace the flow and predict the impact of changes that are likely to occur in scientific ad technical communication as a result of changes in, for example, copyright legislation, library automation and page charge policy. This model will also specifically provide data and analyses on the impact of Federal funding on scientific and technical communication.

#032

The Demand for Information by Rational Agents and the Market for Information. *University of Michigan*, Department of Economics, Ann Arbor, MI 48109. L. E. Blume. $54,645 for 24 months beginning March 1, 1982.

The project covers three separate but related research topics. The first two are concerned with the demand for information and competitive behavior in information markets. In Phase I the researchers plan to introduce noise into the rational expectations equilibrium models by assuming traders make inferences from past information (prices and net trades) as opposed to current price information. In Phase II they will attempt to develop a definition of competitive behavior in economies with costly information. Building upon the knowledge gained in the first two phases, the researchers will then examine the microeconomic foundations of some imperfect macroeconomic models.

#033

Development of a Computerized Decision Support System. *Purdue University*, School of Management, West Lafayette, IN 47907. A. B. Whinston. $240,133 for 24 months beginning June 30, 1981.

In view of the increasing complexity of problems confronting decision makers, the rapid advances in computer technology, and the growing pervasion of computers, the importance of research into computer-based support of decision making is clear. This research seeks to develop a theory of flexible problem solving systems which is applicable to human systems, machine systems, and joint human-machine systems. This problem solving theory forms the basis for developing a general, computer-based decision support system.

Particular emphasis is placed upon the system's problem-solving abilities in terms of problem recognition, model formulation, and executing analyses. These abilities are embodied in the system's problem processor. In addition to the problem processing subsystem, the decision support system contains two other systems. One is the knowledge system where all application-specific knowledge is held. The other is a high-level language system that allows the decision maker to interact with the problem processor.

This project will develop a process model of problem solving that can form a basis for the development of generalized decision support system software, and will investigate design issues within the preliminary problem-solving framework.

#034

Development of a Taxonomy of Representations in Information Retrieval System Design. *University of Rochester*, 410 David Kinley Hall, 1407 W. Gregory Street, Urbana, IL 61801. L. C. Smith. $29,960 for 12 months beginning July 15, 1982.

This project is developing a taxonomy of representations used in information retrieval systems. The representations will be identified, characterized, compared, and evaluated. The identification will include the enumeration of both the categories of representations and the different members of each category. Categories must provide for representation used for documents, queries, data bases, experience of previous users, and user models. The characterization of representations involves the identification of properties which can be used to characterize the members of each category. Comparison and evaluation involves the identification of measures which may be used to compare representations within a category or evaluating the impact of representations on system performance.

#035

Discourse Models for Extended Person—Computer Interaction. *University of California*, Department of Electrical Eng. & Computer Science, La Jolla, CA 92093. R. Reichman. $92,840 for 24 months beginning December 21, 1981.

This research is concerned with computer modelling of extended discourse. Persons engaging in the communicative process expect their co-coversant's to share a set of conventionalized rules for well-formed discourse development. Simulations of person-computer interactions reflect that when interacting with a computer, a person expects these same rules of discourse management to apply. Initial work by the author has demonstrated the feasibility of designing a computational system of extended discourse that can effectively capture the logical/semantic flow of a well-formed discourse and which can model many of the surface linguistic phenomena found therein. The current model, however, assumes that each conversant will follow the other's lead and that each will, at all times, have an identical model of the discourse. Co-conversants, however, do not always construct identical discourse models. Sometimes, conversants immediately adjust their distinct models or match that of a co-conversant's, while at other times, a conversant will persist in using her/his own model. It is suggested that there are rules governing some non-adjustment. These rules are based on the concept of "model compatibility." The defining criteria of model compatibility, and strategies for alternating between models, is a principle aim of the research.

#036

Distributed Information Processing Models of Language Interpretation. *University of Rochester*, Computer Science Department, 617 Math Science Building, Rochester, NY 14627. S. L. Small. $113,606 for 24 months beginning July 15, 1982.

This project will study distributed information processing models of natural language analysis that conform to three principles: (1) language knowledge is specific to particular words and expressions and to their use by particular individuals; (2) by the time an analyzer has examined an entire sentence,

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a large proportion of the effect of reading that sentence should have already been felt in the rest of the information system, and (3) the parsing procedures centers around individual word experts that their lexical interactions in context with each other and with other distributed experts.

A model is being developed which meets these principles. This model will be used to investigate problems of ambiguity resolution, idiom interpretation, analysis of ill-formed syntactic structures, metaphor recognition and interpretation, and induction of word meanings. These solutions will rely on the representation and use of contextual information.

#037

Dynamic Interaction of Multiple Representations: Vision and Language. *University of Massachusetts,* College of Arts and Sciences, Amherst, MA 01003. M. A. Arbib and D. D. McDonald. $174,416 for 36 months beginning May 15, 1981.

Information will be represented in many forms within any complex system. A major task of Information Science is to establish principles which describe the dynamic interaction of these multiple representations in efficient problem-solving. The present project approaches general principles applicable both to human cognition and the design of information systems by focusing on the interaction of linguistic and visual representations in human perception and production of language. Computer generation of natural-sounding descriptions of visual scenes will be studied from the perceptually-oriented representation of a machine vision system. The project will involve computer simulations as well as psychological experiments on language acquisition and written scene descriptions.

#038

Effecs of Mass Media Interpersonal Contact and Social Background in a Rural Cross National Setting: A Longitudinal Study. *University of North Dakota,* Sociology Department, Grand Forks, ND 58202. D. E. Payne. $59,811 for 36 months beginning May 1, 1981.

This research systemizes and extends attitude change and information flow mass communications theories in an international setting and compares international and intranational communication processes. It will answer the questions: What are the cognitive and attitudinal effects of Canadian mass media on American users? How do the effects differ depending on the particular media? How do these mass media effects compare and interact with interpersonal and socio-economic background effects, and are these the same effects that would appear in an intranational setting?

This proposal is for the second (final) phase of a panel study field experiment. Data come from adult populations in three Northern Minnesota locations (N=414). At T_1, one location had received only Canadian television for ten years, one both American and Canadian television, and one only American television. At T_2, all locations have received both Canadian and American television for at least three years. Other Canadian media have been available continuously in all areas. Change in attitudes and conditions associated with media, interpersonal use patterns, and socio-economic background indicate relative effects. Longitudinal trend data are also analyzed.

#039

Efficiency of Sequential Search Algorithms. *City University of New York, Brooklyn College,* Department of Computer and Information Science, New York, NY 10036. A. M. Tenebaum. $84,646 for 24 months beginning March 11, 1981.

This project will examine the efficiency of a class of methods for looking up information, specifically, methods of sequential search with dynamic reordering. Sequential methods are inherently simple, requiring less algorithmic overhead than other more efficient search techniques of the tree search or hash code variety. There are also circumstances in which the latter approaches cannot be used or are best used in conjunction with sequential methods. It is therefore important to improve the efficiency of the sequential approach by allowing an item which has just been accessed to move up to a higher position on the list.

These algorithms will be studied both empirically and analytically to determine their steady state (long run) efficiency and how rapidly that state is achieved. The empirical studies indicate not only direct simulations, but also computations on the Markov processes that represent the search processes more comprehensively than direct simulation.

#040

Evaluating a Knowledge Representation for Planning and Natural Language Understanding. *University of California,* Department of Electrical Eng. & Computer Science, Berkeley, CA 94720. R. Wilensky. $73,184 for 12 months beginning June 29, 1982.

This investigator has developed a theory of planning that may be applied to natural language understanding and to solving complex problems. The theory allows the development of computer simulations in the form of a natural language understanding system and autonomous planner. The planner will be able to construct plans given multiple goals and situations. The programs will use a common, declarative representation of knowledge about the

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world, and knowledge of planning strategies, called meta-planning knowledge.

#041

Evaluation of Telephone Conferencing to Conduct Civil Motion Hearings. *Institute for Court Management*, Denver, CO 80202. B. Mahoney. $186,415 for 24 months beginning May 19, 1981.

The Institute for Court Management, in collaboration with the American Bar Association Action Commission to Reduce Court Costs and Delay, is conducting a twenty-four month study to evaluate the use of telephone conferencing as a method for hearing pretrial motions in civil cases. The principal objective of the research is to assess the consequences of using telephone conferencing, as compared with conventional methods for resolving motions, along four dimensions: quality of the hearing, economic cost outcome of the proceedings, and extent to which participants in the court process are receptive to the innovation and actually utilize it. An experimental test is designed to evaluate the impact of telephone conferencing in one court and quasi-experimental designs are used for five courts.

The results of the research are intended to clarify the advantages and disadvantages of telephone conferencing for all participants in the court process, and should be significant for the formulation of public policy designed to reduce cost and delay in civil litigation. The research should also contribute to the advancement of scientific knowledge in the areas of law, judicial administration, communications and innovation. The project builds on research now in progress under a grant from the National Science Foundation, pursuant to which the collaborating organizations are collecting descriptive information concerning the use of telephone conferencing in American courts.

#042

Experimental Analysis of Factors in the Design of Information Systems for Modelling Engineering/Economic Decisions. *Carnegie-Mellon University*, Pittsburgh, PA 15213. M. G. Morgan. $225,934 for 18 months beginning June 25, 1981.

A decision model consists of the information that an analyst believes relevant to a decision. Besides factual data, such a model represents the analyst's uncertainties, preferences, and assumptions about the functional relationships between variables. It is used to help predict and evaluate the consequences of alternative assumptions and decisions. What design characteristics are important in an information system to support the development of such a model? This question is addressed in the specific context of decision-oriented engineering/economic models. The investigators hypothesize that a successful information system will: (1) allow all data to be represented as probability distributions and all computations to be executed probabilistically; (2) treat the model structure as data so that functional relationships can be defined, examined, and edited interactively; (3) manage simultaneous representation of multiple values and model structures so that alternative model versions may be compared in sensitivity analyses; and (4) support the incorporation of documentary and explanatory text within the model as it is developed. These hypotheses will be explored using an experimental information system based on an existing prototype as a test bed. Four different organizations have agreed to act as experimental users to provide evaluation in a realistic environment.

#043

Experimental Analysis of Factors in the Design of Information Systems for Modelling Engineering/Economic Decisions. *Carnegie-Mellon University*, Department of Engineering & Public Policy, Schenley Park, Pittsburgh, PA 15213. M. G. Morgan. $8,723 for 0 months beginning April 1, 1982.

This award provides additional funds to NSF Grant IST 81-12439 for purchasing a micro-computer.

#044

Experimental Research on Knowledge Representations for Lexical Disambiguation of Full-Text Sources. *SRI International*, 333 Ravenswood Avenue, Menlo Park, CA 94025. R. A. Amsler. $129,951 for 24 months beginning June 14, 1982.

This proposal is to develop a knowledge representation for use in the disambiguation of lexical items from full text sources. The work will be based on machine readable lexical data which will be derived from lexical word lists and machine readable full texts of dictionaries. The knowledge representation will be based on semantic networks and case grammars. This knowledge representation will then be used to create specific instances from the full text of existing lexical data and then the experimental application of such knowledge representation for the disambiguation of full text items will be examined.

#045

Explanatory Schema Acquisition. *University of Illinois*, Coordinated Science Laboratory, Champaign, IL 61820. G. DeJong. $116,855 for 24 months beginning December 11, 1981.

This research is investigating how a computer might learn to understand the world through its own experiences. The problem is being analyzed within the framework of a natural language processing system. The basis for understanding natural language in this system is the concept of schema based on chunks of knowledge. Schema have already been proven successful, but the issue of how schema are learned has been neglected.

Explanatory Schema Acquisition is a form of learning from direct experience. It will enable a computer system to acquire and refine new schema. This will improve processing efficiency and extend the range of understanding. The research is exploring an indispensable facet of intelligence, the ability to extend one's understanding; it is attempting to relieve the natural language system builder from the task of programming the required world knowledge; and it is examining schemata from the vantage point of learning to help understand the required organization of schematized and non-schematized knowledge.

#046

Extended User-System Dialogues for Complex Information Retrieval. *University of Rochester.* Department of Computer Science, Rochester, NY 14627. J. F. Allen. $199,930 for 24 months beginning July 22, 1982.

This project is examining a system's ability to take part in extended English dialogues within a specified range of topics. This is a requirement for developing information retrieval systems where the information needed is so complex that it can only be found through extended interaction.

The basis of the study will be the use of "plan recognition techniques" to analyze the user's intentions. This work will integrate plan recognition techniques with recent theories on the structure of discourse and extend an existing representation language in order to provide more general reasoning about beliefs, time, and actions.

The plan recognition process will be divided into two levels of goals: the communicative goals and the task goals. The recognition process at both levels will run in parallel and be tested on extended dialogues in the computer operator/user domain.

#047

Factors Related to Use of Scientific and Technical Information and Effectiveness of Engineers: A Longitudinal Study. *Polytechnic Institute of New York*, Organizational Behavior Program, Brooklyn, NY 11201. H. G. Kaufman. $10,000 for 6 months beginning June 8, 1981.

This 24-month effort will attempt to measure the effectiveness of scientific and technical information transfer and use in terms of the job performance of engineers. The reseach will focus on: (1) characteristics of individual users, the nature of their work and their organization; (2) use of specific STI channels; (3) intervening variables that are related to the use of STI channels; and (4) job performance of technical users.

The research will be based on existing longitudinal studies of engineers in six organizations. A follow-up study of these engineers will use the critical incident technique to measure characteristics of information use and supervisory evaluations to determine user-effectiveness. A system-level model to integrate these variables will then be constructed and tested.

As a result of developing and validating such a model, improved guidance is expected to be available for R&D organizations to help them determine changes in their information policies and practices that will increase the performance of their technical professionals.

#048

Flexibility and Efficiency of Knowledge Representation in Intelligent Information Systems. *Temple University*, Department of Computer and Information Science, Philadelphia, PA 19122. R. B. Banerji. $79,298 for 24 months beginning July 30, 1981.

An intelligent information processing program requires a knowledge base. Programs to carry out a very specific task may have the knowledge incorporated in the program itself, while intelligent programs capable of handling a wide range of problems have their knowledge stored in a versatile, complex data structure which the program has to process. This entails a trade-off between the flexibility of a program and its efficiency: versatile programs tending to be less efficient. The purpose of this research is to investigate as to how much of this trade-off is inherent and how much is avoidable. The initial phase will consist of comparing different question-answering and learning programs by embedding the structures of their databases into one uniform structure of larger flexibility.

#049

A Framework for User-Oriented Adaptive Document Retrieval Systems. *University of Massachusetts*, Computer and Information Science Department, Amherst, MA 01003. W. B. Croft. $121,240 for 24 months beginning December 11, 1981.

Many effective search strategies are available for document retrieval systems. However, it does not appear that there is a single most effective strategy. Instead, different strategies perform optimally under different conditions. This project designs and implements an adaptive document retrieval system that chooses the best search strategy for a particular situation and user. In order

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to be able to support a variety of search strategies, a general network representation of the documents and terms in the database is established. This network representation provides efficient methods of generating and using document and term classifications.

One of the most desirable features of an adaptive system is its ability to learn from experience. A method of incorporating this learning ability into the system and experiments for testing the effectiveness of this method are developed in this project. An adaptive control strategy for choosing search strategies enables the system to base its actions on a number of factors, including a model of the current user.

A flexible interface for casual users is included. Part of this interface is the heuristic search, which is used when searches based on formal models have failed. The heuristic search provides a browsing capability for the user.

#050

A Functional Representation of Visual Information. *Massachusetts Institute of Technology*, Artificial Intelligence, 77 Massachusetts Avenue, Cambridge, MA 02139. S. Ullman and L. Vaina. $151,183 for 26 months beginning April 1, 1982.

This project is examining the representational problems posed by adding notions of use, purpose, and function to the information obtained from the sensory analysis. This functional representation is concerned with the recognition of (1) actions—which are purposeful movements whose consequences can be visually identified and (2) objects—which are visually describable shapes grouped by their function or use in actions. The approach to the problem is novel in that (a) it starts with shape descriptions that are derivable from the image and (b) culminates in a representation that depends both on shape description and on the purpose of the viewer. To carry out these research tasks, algorithms capable of processing information derived from visual input will be designed and implemented. Their performance will be compared with that of the human processor who deals with the use of objects and actions.

#051

Geometrical Structure in Perceptual Systems. *University of California*, School of Social Sciences, Irvine, CA 92717. T. Indow. $90,075 for 24 months beginning April 10, 1981.

Human perception of spatial patterns and color relationships is intrinsically geometric in nature. This project will undertake theoretical and empirical studies to explore the extent to which visual space and color space are interpretable within the framework of an already known geometry. The methodology to be developed will be of use for information science in general since it will make explicit the possibility and limitation of giving orderly representations to other domains of complex cognitive information structures.

#052

Group Travel to the Fifth International Information Retrieval Conference: West Berlin, May 1982. *Louisiana State University*. 99 University Lakeshore Drive, Baton Rouge, LA 70803. D. H. Kraft. $10,000 for 6 months beginning April 20, 1982.

Sponsored by the West German Society for Information and Documentation, and in cooperation with the British Computer Society and the Association for Computing Machinery (U.S.A.), the Fifth International Information Retrieval Conference will be held in West Berlin, Germany, May 18-20, 1982. The main scope of the conference is to discuss research results and problems related to the storage, access, and retrieval of non-numeric information. Of the four previous conferences, three were held in the United States, and one in the United Kingdom. The group travel award provides funds for about ten U.S. scientists with recognized expertise in information science and technology to participate in the conference.

#053

Growth of the Communication Sector and Productivity of the American Economy. *National Planning Association*, 1606 New Hampshire Avenue, Washington, DC 20009. N. Terleckyj. $53,707 for 12 months beginning November 6, 1981.

The communication sector is one of the strongest components and a major source of strength of the American economy today in terms of its own growth and because of the contributions it makes to growth in output and productiviy of other sectors. There has been little economic analysis of the dynamics of the communication sector or its impact on the rest of the economy. This project develops an economic model of the growth of the communication sector, explicitly integrating private and public R&D expenditures for communication and electronic components with productivity growth. A second objective is development of an analysis of productivity growth of other sectors of the economy which treats communication inputs as a factor of production, similar to the treatment of energy inputs in a number of recent analyses. This study utilizes data on telecommunication inputs obtained from the U.S. input-output matrices for a number of sectors and industries. At the aggregate level this analysis also includes an estimate of the computer inputs utilized in the private business sector.

#054

The Home Information Utility: Individual-Level Basis of Societal-Level Impact. *University of Minnesota,* School of Journalism and Mass Communication, Minneapolis, MN 55455. J. Ettema. $54,403 for 9 months beginning July 30, 1982.

The research examines the behavior of individual home information utility users in an attempt to better understand the potential social impact of this new communication medium. Specifically, the research explores the ways in which users exploit the technology to enhance the effectiveness of their information seeking activities by, for example, expanding the scope of their searches or routinizing some information seeking tasks. The research also assesses the impact of the utility on the equity of information disribution among users. Subjects of the research are farm families in three Midwestern communities who have access to an experimental videotext system which offers news, community events, weather reports, agricultural market reports, other agricultural news, electronic funds transfer and home shopping.

#055

The Impact of Subject Switching—An Assessment. *Battelle Columbus Laboratories,* Computer, Information Systems, and Education Department, 505 King Avenue, Columbus, OH 43201. R. T. Niehoff. $144,000 for 16 months beginning January 26, 1982.

The investigator's prior research on subject switching has focused on an automated process for facilitating the formulation of search strategies for questions which require the user to search more than one database. It was designed to minimize the effort, increase the quality and decrease the time required to develop such strategies.

The objective of this research is to evaluate an experimental vocabulary switching system as an operative in the query process in three distinct areas: (1) the effectiveness of default switching strategies, (2) the usefulness to intermediaries as a query search construction aid, and (3) the net impact of the system on retrieval quality and usefulness to the end user.

Applications of computer-assisted search-strategy formulations will become increasingly important as libraries and information centers rely more heavily on online systems for access to the published literature.

#056

Incorporating Structure and Semantics into Relational Databases. *State University of New York,* Stony Brook, NY 11794. E. Sciore. $53,821 for 24 months beginning June 17, 1981.

For the information in a database to be used effectively, it must be organized in a readily comprehensible way. It is the job of database theory to help the database designer find appropriate structures for various subject matters. It is the objective of this research to devise information structures which bear some abstract similarity to the way people tend to view the data, thereby easing the task of both the designer and the user.

Three specific aspects of the work are the formalization of a nation of naturalness of semantic structures for databases, the treatment of null values, and the problem of context specification.

#057

Inducing Lexical Definitions for Work-Base Parsers. State University of New York at Stony Brook, Department of Computer Science, Long Island, NY 11794. M. A. Jones. $74,757 for 24 months beginning June 16, 1982.

This research addresses the problem of learning lexical definitions to automate the construction of word based language parsers. Word-based parsers for natural language are controlled by expectations of syntactic and semantic form. These expectations are associated with words and their definitions as specified in a lexicon. This study will use a learnable representation for word-based definitions. The learning mechanism will be to induce "sense hypotheses" for words from sentence-meaning pairs. Word sense expectations may then be shared among a class of related words.

#058

Information Correlates of Basic Language Structures. *Columbia University,* Center for Social Sciences, New York, NY 10027. Z. S. Harris. $115,471 for 0 months beginning December 16, 1980.

This project is part of an ongoing effort to determine the informational structure of language. The research is aimed at reducing the information expressed by word-structure (morphology) to the already established information expressed by words combining into a sentence (syntax). Preliminary investigations suggest that this can be done, and have developed methods for doing it.

The whole work rests on a method of analyzing the structure and information of language which has shown that two processes—distinguished by objective and computable criteria—go into the construction of every sentence: one a direct informational—processing of combining words, and the other a computable process of reducing low-

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information words which does not change the meaning of the sentence. The present project aims to extend this analysis to the internal structure of words.

Such an extension would show that morphology contains no information not contained in syntax. Hence it would show that the known process of combining free simple words into sentences carries all the information carryable by language. It would also give the starting point for computer programs to replace complex words by constructions of simple words, in any computer processing of written information.

#059

Information Models for Reconstructive Memory and Learning. *Yale University*, Department of Computer Science, Box 1504A, Yale Station, New Haven, CT 06520. R. R. Schank. $80,950 for 12 months beginning February 16, 1982.

Research on inference and memory processing within artificial intelligence systems generally has omitted the issue of learning, and learning theories have tended to ignore information processing in memory. This investigation is taking the viewpoint that memory processing and learning are integrally related and should be accounted for by a unified theory. This project is exploring this theoretical framework by constructing computer-based models that remember and learn. The consequences of these theories on how memory's information structures effect learning and the effects of learning on memory's information structures are being considered.

#060

Information Processing Analysis of Human Understanding of Action Sequences and Computational Traces. *Rutgers University*, Laboratory for Computer Science Research, New Brunswick, NJ 08903. C. Schmidt. $91,885 for 12 months beginning April 20, 1982.

This research is focused on the investigation of how human actions are understood. It is concerned with the development of a methodology and the use of this methodology to test predictions from an information based theory of the human's action understanding process.

Knowledge of how the human understands the actions of other individuals is important for the development of effective human-machine interaction and for the construction of information structures which allow intelligent interaction.

#061

An Information Processing Analysis of Learning Geometry. *Carnegie-Mellon University*, Department of Psychology, Pittsburgh, PA 15213. J. R. Anderson. $259,742 for 36 months beginning January 29, 1981.

A theory of human information processing will be tested in the domain of acquisition of theorem-proving skills in geometry. The specific skills investigated will be reason-giving and the generating of steps in a proof. Traditionally the former is used to introduce the latter, but the theory assigns these two skills very different information processes. Special experimental software will be developed both to study the skill acquisition and to direct its development.

The theory to be tested is the investigator's "ACT" model which comprises a propositional network representation of declarative knowledge and a production system model of procedural knowledge. This general approach will be rendered more explicit in a simulation model. The simulation will be guided by analyses of protocols of students engaged in acquiring the skills.

#062

Information Processing in Algebra and Computer Programming. *Yale University*, Department of Computer Science, New Haven, CT 06520. E. M. Soloway. $125,480 for 24 months beginning June 17, 1981.

To solve a problem posed in natural language a person must carry out an information-processing task that takes the linguistic input and yields an output expressed in a different system of representation, such as algebraic equations or a computer program. This process requires the extraction of relevant information from the problem, and a translation from an input language to an output, solution language. It implicitly requires an understanding of such terms as *variable*, *function*, and *operation*. Although in mathematics and computer science these words have a formally defined syntax and semantics, it is not clear that what people actually understand by these notions is the same as the formal descriptions. The objective of this research is to characterize the extraction and translation processes, and the various meanings people actually have for the above basic concepts.

The approach is to compare and contrast the process people follow in reaching an algebraic versus a programming solution. Because the former domain calls for a structural solution, and the latter domain a procedural solution, this approach provides important leverage into the underlying knowledge structures and reasoning processes. Indeed previous empirical work has shown significant performance differences on problems identical except for the form of solution required. The methodology includes both testing and videotaped interviewing of college students, primarily drawn from science, engineering and business disciplines.

#063

Information Science: An Analysis of Methodological Issues and Interdisciplinary Relationships. *New York University,* Department of Economics, Arts, & Science, New York, NY 10003. F. Machlup. $18,820 for 9 months beginning April 14, 1982.

This is a supplement to Grant No. IST-8008007. The objective of this research is to examine and define the interrelationships that exist among the various disciplines that are regarded as constituent of, related to, or complementary with information science. Information science is not a mature discipline and the investigations of how humans transmit, receive and transfer knowledge have not been integrated into a set of coherent theories.

The original project included plans for 7 or 8 experts to prepare papers on their different specialties. This number has now reached 9. Most of these papers have been written or are in the final stages of completion (March 31, 1982 deadline). After considerable time and effort, Machlup determined that the synthesis of these papers that he planned to do was inadequate. He now intends to subject each position paper to review by 4 or 5 experts who will prepare commentaries. Three of these were distributed previously for comment; the remaining 6 will be distributed in the next few weeks. Each author will be invited to submit a rejoinder.

All of the papers, commentaries, and rejoinders will be published in a special issue of the journal *Knowledge: Creation, Diffusion, and Utilization.*

#064

Information Science and Economic Theory. *New York University,* Engineering Economic Systems, Washington Square, New York, NY 10003. R. N. Langlois. $38,609 for 12 months beginning November 27, 1981.

This research will examine the potential contribution of information science to economy theory. Drawing on the insights gained, the project will develop models, including mathematical ones, if appropriate, that bear on the economics of modern information technology.

The research consists of 3 major steps. The first is an analysis of the ideas represented in recent work in information science; the second will consider modelling issues; and the third will be an analysis of a specific problem related to modern information technology, stressing the analytical and normative points of divergence from the results of more conventional analyses.

#065

Information Structure of a Natural Language Lexicon. *Brandeis University,* Department of Psychology, Waltham, MA 02254. R. Jackendoff and J. Grimshaw. $24,238 for 12 months beginning April 20, 1982.

This study focuses on the question of how information about lexical items is shared between semantic and syntactic modes of representing natural language. Since the human memory as a text processing device must store and process linguistic information then linguistic theories of information provide a lower bound on the complexity of an information theory of memory. Semantic representations are taken to be a characteristic of cognition as a whole. Thus the results of this study are important to the study of general purpose vs. capacity specific information structures.

#066

Information Structure of a Natural Language Lexicon. *Brandeis University,* Department of Psychology, Waltham, MA 02254. J. Jackendoff and J. Grimshaw. $20,809 for 0 months beginning July 12, 1982.

This study focuses on the question of how information about lexical items is shared between semantic and syntactic modes of representing natural language. Since the human memory as a text processing devise must store and process linguistic information then linguistic theories of information provide a lower bound on the complexity of an information theory of memory. Semantic representations are taken to be a characteristic of cognition as a whole. Thus the results of this study are important to the study of general purpose vs. capacity specific information structures.

#067

An Information Theoretic Approach to Reading. *University of Kansas,* Department of Psychology, Lawrence, KS 66044. S. Kemper. $76,989 for 24 months beginning July 20, 1981.

This research will investigate reading as a form of information processsing between reader and text. Emphasis is on comprehension as the product of the interaction of the reader and large units of prose such as sentences, paragraphs, stories and articles. The project involves three main tasks: (1) the development of a method for specifying the difficulty or readability of prose; (2) the validation of this method with readers who differ in age, reading skill, and background knowledge; and (3) the investigation of interactions between reader and text during reading. Experiments will involve public school children from the second, fourth, and eighth grades, and University undergraduates.

The investigator is concerned with the demand inference making places on reader's information processing systems. The inference load model identifies three sources of reading failure: the connectedness of the event chain, the explicitness of the connections, and the density of information in the text. Temporal analysis of oral reading and question-answering will be used to identify sources of reading difficulty. By measuring pause times and reading rates and by monitoring accuracy and latency to response to both factual and inferential questions it will be possible to identify inferences readers make during reading as a function of the structure of texts and reader's knowledge and experience.

#068

Information Theory of Equilibrium Processes and of Regulatory Systems. *Northwestern University,* Department of Mathematics, Evanston, IL 60201. D. G. Saari. $46,592 for 24 months beginning February 12, 1982.

The objective of this research is to develop an information theory for economic systems with implicitly defined performance functions. A secondary objective is to extend the framework of information theory to include certain types of regulatory systems.

Two types of problems will be examined. The first kind of problem concerns resource allocations that result from a given equilibrium concept, e.g., allocations corresponding to Pareto optima points, core points and other solutions concepts from game theor. The second type of problem is important to the design of regulations. The goal here is to impose constraints on an existing system or to design a process that results in resource allocations that are consistent with predetermined objectives.

#069

Informational Aspects of the Adoption and Diffusion of Innovation. *Ohio State University,* Department of Economics, 1775 College Road, Columbus, OH 43210. R. A. Jensen. $39,771 for 15 months beginning July 2, 1982.

The purpose of this research project is to provide a rigorous analysis of several important informational aspects of the diffusion of an innovation throughout an industry. Specifically, this research examines how a firm's decision to adopt an innovation and the probability that it will adopt at any specific time are affected by its ability or capacity to gather information about the innovation, the experiences of rival firms with innovation, the cost of acquiring information, and the change in its market share resulting from leading or lagging behind its rivals in adoption. The fundamental premise underlying the analysis is that firms do not know with certainty whether an innovation will be profitable or not, and must obtain information to learn about its profitability. The methodology employed in stochastic dynamic programming, which has been used extensively by economists concerned with the theory of search for the best alternative. The significance of the project derives from the fact that, although empirical studies of innovation diffusion invariably point out the importance of information and learning to the process, economists have not yet developed rigorous theories explaining how information affects an individual firm's adoption decision.

#070

Innovation and Efficiency in Spectrum Management Theoretical Analysis. *Stanford University,* Department of Engineering/Economic Systems, Stanford, CA 94305. C. E. Agnew. $132,436 for 14 months beginning June 23, 1981.

Technical and service innovation, growth of demand for spectrum-based telecommunications services, and general interest in deregulation have prompted consideration of economics-based techniques for spectrum management. This project is a theoretically-oriented exploration of market conditions relevant to spectrum-based innovations, including the following: adaption of incentive compatible allocation mechanisms to assignments of geostationary orbit-spectrum; impact of network externalities on the outcomes of spectrum management arrangements; relationships between price, quality and growth of an innovative spectrum-based service. These areas are approached using economics, systems engineering, and decision theory.

#071

Interrelationships Between Federal Funding and Production of Scientific Papers. *Computer Horizons,* Cherry Hill, NJ 08034. P. R. McAllister. $95,163 for 12 months beginning April 14, 1981.

This research is aimed at developing and testing an econometric model that will provide a means of quantitatively assessing the effects of fluctuations in Federal research support on publications output. The model will be developed using three kinds of biomedical data: research funding figures, publication counts for 49 biomedical subfields and cross-subfield citation counts for the 49 subfields. The reliability and accessibility of these data make them particularly attractive for this research undertaking. Specifically they will permit an examination of the relationships between Federal funding funds and the production of journal articles, the interdependence of various subfields and the relationship between funding and the level (basic/clinical) of research papers produced. The results of this model will be of value to policy makers as they seek to determine the impact of alternative funding decisions in research.

#072

Intervening in Markets on the Basis of Imperfect Information: An Information Theoretic Approach. *California Institute of Technology*, Division of Humanities & Social Sciences, 228-77, Pasadena, CA 91125. A. Schwartz. $98,980 for 24 months beginning January 13, 1982.

The research is attempting to answer three questions: (i) how do the strategies consumers use to acquire and process information about purchase choices affect market outcomes? (ii) how can decisionmakers determine when markets are badly behaved because consumers are acquiring insufficient information? (iii) what strategies and technologies are appropriate to move markets to competitive equilibria? These questions are dealt with in three ways: (a) construction of a set of equilibrium models of how consumers search for prices and contract terms; these models shall rest on relatively realistic assumptions respecting how consumers and firms behave when faced with uncertainty; (b) testing the predictions of these models in experimental laboratory markets and later in actual markets; (c) deriving from theoretical and empirical results a more realistic set of criteria than now exist by which decisions can evaluate existing markets and choose appropriate strategies to improve market performance. This research program is designed to provide a richer understanding of how environments characterized by costly information behave and how modern technologies for transmitting information are likely to affect these environments.

#073

Investigation of Models for Enhanced Information Retrieval Through Computer-Mediated Assistance. *Massachusetts Institute of Technology*, 77 Massachusetts Avenue, Cambridge, MA 02139. R. S. Marcus. $97,445 for 12 months beginning February 5, 1982.

This research is investigating and developing models of document retrieval. The purpose is to aid in the information search process and to improve information retrieval operations by designing an advanced user assistance system, an intermediary system. The creation of effective intermediary systems has the potential of modifying existing information system use patterns by reducing the user's dependency on a human information specialist. Five aspects of the models will be examined in this study: (1) computer-assisted problem presentation; (2) automatic transformation of a problem representation into an information search strategy; (3) automatic information search execution; (4) computer-assisted search evaluation; and (5) computer-assisted information search reformulation. An experimental intermediary system based on these five characteristics, will be used as a tool to evaluate how well the model encompasses optimal search elements in a human-information system environment.

#074

Judgmental Inference in Understanding Textual Information. *University of California*. R. H. Granger. $64,158 for 12 months beginning June 16, 1982.

Understanding textual information requires the reader to make inferences about things implied but not explicitly stated in the text. Since inferences generated during understanding are educated guesses, and not logical deductions, a careful reader must be able to evaluate inferences in order to ensure that they are still applicable in light of subsequent information. Most existing natural language understanding systems lack this "self-referential" ability.

This research is developing a theory of judgmental inference to account for people's ability to re-evaluate their own inferences in light of new information. The investigation includes the kinds of evaluation measures people possess for judging inference nets, how this knowledge is structured, and how it is used in text comprehension.

#075

Knowlege: Its Creation, Distribution, and Economic Significance. *New York University*, Department of Economics, New York, NY 10003. F. Machlup, $173,493 for 24 months beginning May 29, 1981.

The results of this empirical research will be incorporated into Machlup's 8-volume series on *Knowledge and Knowledge Production*. The research will provide series on the annual cost of the various branches of the knowledge industries, including: information services and information technology; communication media; research and development; and education. The major quantitative results will examine the share of GNP represented by knowledge creation and distribution, and the growth rates of the aggregates and subaggregates from the 1940's to the present.

#076

A Knowledge-Based Approach to Intelligent Interactive Help Systems. *University of Pennsylvania*, Department of Computer and Information Science, Philadelphia, PA 19104. T. W. Finin. $99,544 for 24 months beginning December 23, 1981.

As the use of computer-based information systems increases, so does the need for an intelligent, cooperative interface between system and user. One aspect of the system-user interface is the help system, which provides the user with on-line assist-

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ance. Today's help systems incorporate an impoverished dialog model and little understanding of the task domains in which they are employed. This research investigates the design of an interactive help system which uses a cooperative, mixed-initiative style of dialog based on a richly detailed representation of a task domain, of an information system's functions, and of a user's knowledge of the system. An experimental help system for an appropriate computer-based information system will be implemented using the KL-ONE knowledge representation system.

#077

Longitudinal Study of Computer Technology and Impact in Cities. *University of California,* Campus Drive, Irvine, CA 92717. K. L. Kraemer. $185,572 for 24 months beginning March 25, 1982.

This research will undertake a longitudinal evaluation of computing in organizations in order to: (1) empirically determine whether computing use and policies for computing management in organizations evolve along predicted "stage theory" dimensions, and if so, whether the stages described in these theories correspond to the stages discovered in the research, (2) investigate the "performance dynamics" of computing in organizations as the basis for assessing whether specific policies devised to achieve the benefits and alleviate problems with computing in fact do so, and if now why, and (3) empirically describe the diffusion of computing innovations in organizations as a template against which future computing growth in organizations can be assessed. The research focuses on U.S. cities as its "laboratory" for data collection and analysis. It will replicate key aspects of a nation-wide study conducted in 1976, which focused on the relationship between environment, policy and impacts from computing. The outcomes of this research will have substantive policy utility for computing-using organizations generally, for policymaking about the diffusion of computing innovations by federal and state government agencies and the computer industry. The research results should apply to problems in computing system and applications design as well as to information management and organization.

#078

Managing Text as Data. *Relational Technology Inc.,* 2855 Telegraph Avenue, Suite 515, Berkeley, CA 94705. R. Kooi. $29,876 for 6 months beginning September 21, 1982.

Relational database management systems, such as INGRES, now provide users with unprecedented power to access and manipulate data. Yet, as they exist, these systems are of little use in applications involving text. Superficially, this is because text lacks the degree of structure needed for their effective operation. More deeply, it is because they can represent text only as strings of characters and must therefore ignore most of its semantic content. In this project, new data types capable of recognizing that content are investigated. The approach taken is to use existing INGRES structures to represent the new types and their associated operators without implementing them explicitly. The resulting capabilities for searching, excerpting, indexing, and analyzing text will be explored with a representative collection of textual material. The results are expected to have widespread application in database and DBMS design and in office automation.

#079

Mathematical Models in Automatic Information Retrieval. *Cornell University,* Department of Computer Science, Ithaca, NY 14850. G. Salton. $132,054 for 24 months beginning July 14, 1981.

A great deal of knowledge has been accumulated over this last decade about the design and operations of standard Boolean retrieval systems. Recent research results have led some researchers to believe that use of weighted document terms will result in more effective information retrieval than unweighted terms, and that term dependencies should be incorporated into the indexing and retrieval processes. This research builds upon this assumption and is aimed at achieving a better understanding of and improving the design of information retrieval systems.

The first two phases of this research are concerned with the processing of Boolean queries when weights are assigned to document and query terms, and enhancing retrieval performance through an investigation of optimal term relevancy weights. Building upon knowledge gained in phases 1 and 2, the researchers will design information retrieval systems using various representations of document scope. They will then conduct experiments to compare the operations of these enhanced retrieval systems with the standard retrieval methods based only on content terms.

#080

The Mental Representation of 3-D Space. *Stanford University,* Stanford, CA 94305. S. Pinker. $84,883 for 17 months beginning June 23, 1981.

The notion that mental images are like two-dimensional pictures is severely strained by people's remarkable ability to represent and mentally transform 3-D space and objects. In this research project, experimental tests are carried out for a theory of the mental representation of space positing that:

1) Visual space is represented in an internal 3-D array, with cells representing the direction and distance of visual field locations relative to the viewer. Scenes are represented as patterns of filled and unfilled cells isomorphic to the projected shapes of the represented objects. 2) Each cell has 2 addresses, one corresponding to the viewer-centered coordinates of that location, the other to world-centered coordinates of that location. 3) The origin of the world-centered coordinate system can be reassigned within the array. According to the theory, viewer-centered coordinate system can be reassigned within the array. According to the theory, viewer-centered addresses are critically involved in top-down pattern recognition, attention, eye movements, and perspective judgments; object-centered addresses are involved in bottom-up pattern recognition, mental transformations, perceptual stability, and intrinsic size and shape judgments. The theory is tested in a set of experiments measuring the time people take to generate, inspect, and transform mental images, time to detect and classify visual stimuli, accuracy of recall of imagined objects, and accuracy of psychophysical judgments about imagined locations.

#081

Modeling Contextual Language Understanding. *University of California,* Department of Electrical Engineering and Computer Science, Berkeley, CA 94720. R. Wilensky. $124,433 for 24 months beginning November 10, 1980.

Computer-based information processing systems are notably weaker than humans in domains that require an understanding of human intentionality. It is proposed to work toward remedying this situation, by positioning a structure of intentionality and letting it play a role in processing natural language input. A preliminary theory of the role of intentionality in natural language processing has already been developed and used as a basis for a natural language understanding system. However, a great deal of additional work is needed to extend the theory and program to handle more sophisticated natural language texts. The results of this research should shed light on the cognitive mechanisms people employ in language understanding as well as yield a computer system whose understanding capabilities exceed that of existing systems.

#082

Modeling of Human Behavior in Seeking and Generating Information. *Georgia Institute of Technology,* School of Industrial and Systems Engineering, Atlanta, GA 30332. W. B. Rouse. $60,000 for 12 months beginning September 2, 1981.

The long range goal of this research is to develop analytical techniques that are applicable to the design of computer systems that understand their users and can adapt the human-computer interface so as to best meet the needs of the particular human using the system at the moment.

Development of mathematical models of human behavior in information generation and retrieval will be undertaken. The specific tasks to be studied include text editing and searching/browsing through databases. Both rule-based and decision theoretic models will be developed based on analysis of actual keyboard entries. The resulting models will be useful for various applications, especially in the area of training.

This project was originally funded as NSF Grant IST 79-16471 to the University of Illinois, and was transferred to the Georgia Institute of Technology when the investigator accepted a faculty position there.

#083

Modelling of Generalizations of Boolean Query Processing in Retrieval Systems. *Louisiana State University,* Department of Computer Science, Baton Rouge, LA 70803. D. H. Kraft. $34,722 for 12 months beginning July 23, 1981.

The research is directed toward establishment of a mathematical model of an information storage and retrieval system. The system communicates in terms of questions with yes-or-no answers and employs a form of indexing that allows for differing weights depending on the importance of particular items. One extension of the theoretical capabilities under investigation is allowing the user to specify various degrees of relatedness between documents and the topic he is searching on instead of being constrained to a simple yes-or-no evaluation. A similar extension is under investigation for the relation between user topic and terms, so that a user would be able to state, in effect, that some of the terms he has given the system to search on are more critical to his needs than others. The research includes the development of appropriate measures of performance utilizing the framework of the model.

#084

Models of Information in Industrial Organization. *Carnegie-Mellon University,* Graduate School of Industrial Administration, 5000 Forbes Avenue, Pittsburgh, PA 15213. C. Spatt. $25,000 for 24 months beginning July 21, 1982.

The purpose of this project is to enhance understanding of an array of phenomena in industrial organization based on informational concerns, and to advance the methodology used in dynamic models of information in economics. Several lines of research are pursued as follows: the endogenous

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incentive of firms with good past returns (conveying favorable information about the distribution of future project opportunities) to maintain a good credit reputation; competitive models of effort choice in which insurers and the insured learn about the accident rate from accident realizations (moral hazard and adverse selection considerations will be treated); and dynamic models of price discrimination will be analyzed in which the consumers recognize that the firm will subsequently exploit inferences about their characteristics revealed by past consumer contract choices. Two areas of research on static price discrimination are examined; understanding why in many environments only a limited degree of discrimination arises, and examining the qualitative contrast between models with one seller and many sellers.

#085

Natural Computation and Control. *Massachusetts Institute of Technology*, Department of Psychology, Cambridge, MA 02139. W. A. Richards. $411,972 for 12 months beginning March 27, 1981.

Research in natural computation explores the information processing mechanisms utilized by biological systems in performing basic sensory and motor functions. The MIT effort is primarily concerned with understanding the computational mechanisms which underlie the human visual system's representations of the external world. Topics to be investigated will include: (1) stereopsis, (2) texture, (3) structure from motion, (4) transparency, (5) color perception and normalization, and (6) derivation of object shape from contour and shading.

This project continues research supported by NSF Grant MCS-7707569.

#086

Natural Computation and Control. *Massachusetts Institute of Technology*, Department of Psychology, 77 Massachusetts Avenue, Cambridge, MA 02139. W. A. Richards. $445,716 for 12 months beginning July 29, 1982.

This is the third year of a 3-year continuing grant. The project concerns the study of computational mechanisms that can be used to derive reliable representations of useful aspects of man's environment. These representations may be visual, auditory, or in other forms, although the research of the past two years has focused on mechanisms that underlie vision. Over this 2-year period, the group, headed by Professor Richards, has made significant advances in three general problem areas: (1) the efficient representation of image intensities; (2) the recovery of 3-dimensional shape from static 2-dimensional images; and (3) the recovery and recognition of shape and structure of objects in motion. Projected work in the third year includes a fourth area of research-namely, how object-based representations may be built and indexed. There are also plans to study whether some of the solutions to vision problems have analogies in other sensory areas, especially audition and motion control. Interlacing the vision program with the robotics research at MIT has also been contemplated.

#087

Natural Language Access to Text. *SRI International, Artificial Intelligence*, 333 Ravenswood Avenue, Menlo Park, CA 94025. D. E. Walker. $88,032 for 12 months beginning August 19, 1982.

This project is studying the natural language dialogue procedures to facilitate information retrieval. These procedures analyze a user's request as expressed in English and identify passages from textual material that can be inferred to be relevant to the user's request. This project is examining the inference mechanisms and a procedure which modifies new text so that it can be incorporated into the data base.

#088

Natural Language Interfaces to "Layered" Domains: A Multiple-Prototype Approach. *Duke University*, Department of Computer Science, Durham, NC 27706. B. W. Ballard. $62,598 for 24 months beginning July 15, 1981.

Although recent years have seen important advances in artificial intelligence and computational linguistics, many problems remain to be solved before the goal of truly "natural" language systems is achieved. This reserch will study the class of "layered" domains, which contains many problems of interest and whose semantics and domain structures resemble previous work by the author. Assuming the context of question-answering, two particularly timely issues in natural language system design will be addressed.

1) How can several of the more difficult context-related problems of natural language be handled together in a single system?

2) How can a prototype be built so that applications to new domains can be made quickly, yet without loss of reliability?

To enforce a firm distinction between general and domain-specific aspects of an implementation, three prototype systems will be designed simultaneously for different layered domains. This research is expected to contribute both to theories of natural language understanding and in the area of reliable system design.

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#089

Nonstandard Decision Rules and Information Representations. *University of California-Berkeley*, School of Library and Information Studies, Berkeley, CA 94720. W. S. Cooper. $75,046 for 24 months beginning June 30, 1981.

A class of decision rules will be studied in order to characterize its properties and information requirements. The rules in question arise from a consideration of the implications of standard biological models of the evolutionary process. Because they are biologically motivated, such decision rules might be expected to account for aspects of human decision-making that violate the normative rules postulated by traditional decision and utility theory.

The theoretical approach to be used involves a formal derivation of the decision rules from the evolutionary models, and the identification of ways in which information structure and choice behavior might be expected to differ from the predictions of the traditional theory of rational choice under uncertainty. The possible implications of these differences for the nature of human decision-making will be explored.

#090

On the Role of Information in a Productive Organization. *Northwestern University*, Department of Managerial, Economic and Decision Sciences, Evanston, IL 60201. P. Milgrom. $38,822 for 24 months beginning June 29, 1982.

Organizations are limited in their ability to utilize members' information partly by limits on the human capacity to process information and partly by the problems arising from conflicting objectives between the organization and some of its members.

This research investigates the nature of these limits in productive organizations and how organizations can be structured to cope with them. This is done through a series of six specific problems, which are investigated by the methods of mathematical economics. The first problem is that of noncompetitive performance evaluation, in which a principal must evaluate the performance of his better informed agent. The second is competitive performance evaluation, where the principal can compare the performance of his several agents to improve his evaluation. The third considers the problem of a manager who must allocate his limited attention among several tasks, where attention is the capacity to gather and process information. The fourth problem involves fixing the locus of decision-making in an organization, where there is a trade-off between coordinating decisions and being responsive to local information. The fifth problem is one of eliciting truthful information from interested parties to a decision. The sixth concerns the effect of asymmetric information on the performance of "thin" markets.

#091

Optimal Incentive Schemes Under Asymmetric Information. *University of Pennsylvania*, Department of Economics, Ann Arbor, MI 48109. D. Sappington. $25,655 for 12 months beginning July 22, 1982.

The objective of this research is to examine the properties of optimal incentive schemes and contracts under a variety of changing states of informational knowledge. The analysis will build upon Principal-Agent theory to gain a better understanding of how information is handled in society. The output from this research will be of particular interest to those parties involved in contractual relationships in which neither can be certain of the final outcome of their relationship, be it government agencies and research organizations, regulators and regulatees or doctors and patients.

#092

Organizational Impact of Video-Teleconferencing: Pilot Study. *University of Southern California*, Annenberg School of Communication, Los Angeles, CA 90007. W. H. Dutton. $34,754 for 7 months beginning May 5, 1981.

The objective of this study is to explore the impact of the use of video-teleconferencing technology on organizational decision-making. Technology improvements, telecommunications deregulation, and increased requirements for travel reduction and productivity improvement, suggest more widespread use of video-teleconferencing by organizations. Research on organizational behavior indicates that interactive telecommunications technologies may change communications patterns affecting social processes related to power and decision-making, such as centralization and coalition formation. This pilot study involves constructing and testing measures at several public teleconferencing facilities used by public and private organizations, and preliminary hypotheses testing and further validation via several follow-up case studies in user organization.

#093

Organizational Impacts of Local Information Network Technology. *Georgia State University*, Decision Sciences Laboratory, University Plaza, Atlanta, GA 30303. S. E. Harris. $47,119 for 6 months beginning March 30, 1982.

Advances in information technology have stimulated the development of flexible combinations of computing and telecommunications, called local networks. Deployed to interconnect elements of complex organizations and to provide data manipulation and text retrieval capabilities, local networks are expected to enhance organizational functioning and improve organizational productivity.

This project is to initiate research on the organizational impacts of local networks by exploring the use of the university research setting as a model or laboratory for experimentation on representative local network configurations and applications.

The project has applied and basic scientific components. The applied component is to evaluate alternative network configurations and applications in the local university setting. The basic component is to examine methods to measure the impacts of local networks on knowledge workers.

#094

Partial Payment of Dues from the U.S. for the Committee on Data for Science and Technology of the International Council of Scientific Unions. *National Academy of Sciences*, Washington, DC 20418. G. C. Carter. $12,000 for 12 months beginning June 5, 1981.

The Committee on Data for Science and Technology (CODATA) was established by the International Council of Scientific Unions (ICSU) to improve the quality, reliability, and accessibility of data of importance to science and technology, including not only quantitative information on the properties and behavior of matter, but also other experimental and observational data. CODATA works on a world-wide basis, and is concerned with the physical, biological, and geological sciences, as well as with data of interdisciplinary significance. It has established sets of key data (e.g., fundamental physical constants; thermodynamic and kinetic data), issued directories to sources of data, and recommended formats for reporting data in the literature. It also conducts conferences and training courses.

CODATA has 17 natural members, including the United States, as well as scientific union members. The National Academy of Sciences is the U.S. national member, and exercises this membership through the U.S. National Committee for CODATA, under the NAS Numerical Data Advisory Board.

This award will support approximately one-third of the U.S. annual dues to CODATA for 1979, 1980, and 1981. Support for the remaining portion of the dues will be shared equally by the National Bureau of Standards and the Department of Energy. The U.S. dues to CODATA are currently $31,000.

#095

Partial Support for a Workshop on Information Retrieval, November 18-20, 1980, Washington, DC. *Center for Policy Research*, Washington, DC 20036. S. B. Weiner. $6,538 for 5 months beginning November 20, 1980.

Guided by its organizing committee which consists of the project's Principal Investigator, Dr. Martha E. Williams and Dr. Donald Hillman, the interdisciplinary workshop will address issues on the retrieval of information stored in automated systems. The workshop will bring together experts in information science, computer technology and programming, philosophy, psychology, cybernetics, artificial intelligence, mathematics, and linguistics. The main issues to be addressed are: (1) classes of retrieval problems; (2) new hardware and its impact on storage and retrieval; (3) advances in search strategies and algorithms; and (4) advances in artificial intelligence.

The results of the two-day workshop will be published and will contain papers on the status of the retrieval technology, the technology expected to be available in the next few years, and suggested future research directions. The workshop will be held in Washington, DC, in late November, and is jointly sponsored by the Office of Naval Research.

#096

Partial Support of the Numerical Data Advisory Board (NDAB). *National Academy of Sciences*, Washington, DC 20418. G. C. Carter. $15,139 for 12 months beginning March 17, 1981.

The Numerical Data Advisory Board (NDAB) of the National Academy of Sciences (NAS) provides a national forum for the consideration of the whole range of problems associated with the compilation and dissemination of scientific data. Through the establishment of working groups of carefully selected experts the NDAB carries out detailed studies and submits reports relating to the generation, processing, storage, retrieval and use of critically evaluated data.

The groups are:

- Working Group on a List of Directories;
- Panel on Accessibility and Dissemination of Data;
- Panel on Education;
- Committee on Fundamental Constants;
- Ad Hoc Panel on Mechanical Properties of Data and Alloys.

This project is also supported by the National Bureau of Standards, the Department of Energy, the Department of Defense, and the Environmental Protection Agency.

#097

Partial Support of the Numerical Data Advisory Board. *National Academy of Sciences*, 2101 Constitution Avenue, Washington, DC 20418. G. C. Carter. $30,169 for 12 months beginning November 17, 1981.

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The Numerical Data Advisory Board (NDAB) of the National Academy of Sciences (NAS) provides a national forum for the consideration of the whole range of problems associated with the compilation and dissemination of scientific data. Through the establishment of working groups of carefully selected experts, the NDAB carries out detailed studies and submits reports relating to the generation, processing, storage, retrieval, and use of critically evaluated data.

In addition, NDAB provides administrative support services to the U.S. National Committee for the Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions (ICSU). CODATA was established by ICSU, to improve on a world-wide basis the quality, reliability, and accessibility of quantitative, experimental and observational data.

NDAB's and CODATA's activities promote the application of new information knowledge to improve the storage and retrieval of scientific and technical data.

This project is also supported by the National Bureau of Standards, the Department of Energy, the Department of Defense, and the Environmental Protection Agency.

#098

Performance of Multikey Information Search Algorithms. *Southern Methodist University*, Department of Computer Science and Engineering, Dallas, TX 75275. C. M. Eastman. $17,644 for 12 months beginning July 22, 1982.

This project is examining the performance of multikey search algorithms which are important for the efficient use of information systems. A wide variety of multikey search algorithms exist and may be classified by their matching scheme or their underlying file structure. This research will be focussing on tree-structured algorithms and will develop models of the behavior of this class of algorithms, implement additional new algorithms as appropriate, investigate the algorithm's sensitivity to the distribution of record and query keys, and investigate the sensitivity of search performance to information system design parameters. This research will be applied to the design of information systems requiring efficient search algorithms.

#099

Pilot Testing of Distributed Work Environment Organization and Technology. *New York University*, Graduate School of Business Administration, Washington Square, New York, NY 10003. M. H. Olson. $18,648 for 3 months beginning June 4, 1982.

A three month effort, this work consists of elaborating theory and testing methods to examine the effects on organizational productivity and individual behavior of the use of information technology in a distributed, "remote work" setting. The particular remote work setting is a decentralized office, with some workers from their homes via computers and telecommunications devices. As a pilot effort, it will produce instruments and designs for subsequent research and permit preliminary theory testing.

#100

Productivity Growth and Scientific and Technical Information. *Princeton University*, Department of Economics, Princeton, NJ 08540. W. J. Baumol. $46,592 for 24 months beginning February 12, 1982.

The objectives of this research are to construct a theoretical model and carry out empirical inquiries to determine the nature of the feedback relationship between R&D and its dissemination and the rate of growth of productivity elsewhere in the economy. That R&D affects productivity growth is clear, but both the facts and the data confirm that productivity growth raises real wages and therefore tends to increase the relative cost of R&D, which appears to have an essentially irreducible labor component. The relationship leads to a dynamic analysis which clarifies the role of information and research in productivity growth.

In addition to its contribution to the theoretical foundations of the economics of information, the results of this research will be of value to decision makers who are seeking a better understanding of the productivity slowdown and the options available to them.

#101

Query Logic for a Text-Knowledge Base. *University of Texas*, Department of Computer Sciences, 328 T. S. Painter, Austin, TX 73712. R. F. Simmons. $25,162 for 24 months beginning April 26, 1982.

This research is to define a consistent set of text representations. These representations will be based on a specific scientific text and used for the development of a system of general inference schemas for answering English language queries. The data base will be the Handbook for Artificial Intelligence for which queries will be collected and an inference logic developed for answering these questions.

The results of this project could then be applied in Computer Aided Instruction, Expert Systems, or other text based information systems.

#102

Representation and Utilization of Non-Textual (Chemical Spectral) Information. *Boston University*, Department of Chemistry, 881 Commonwealth Avenue, Boston, MA

02215. M. F. Delaney. $33,000 for 12 months beginning May 6, 1982.

Chemical spectra interpretation is important for the search and retrieval of molecular structures. This project is using aspects of graph theory and information theory to develop a model of this information search process to aid in the identification of a single compound from the millions of known compounds. The model allows the assessment of "power" for various methods, optimization of storage and comparison parameters, and facilitates the prediction of library searching performance.

#103

Representation of Information and Ease of Update: A General Theory of Relational Data Base Normalization. *University of Vermont*, Burlington, VT 05401. S. J. Hegner. $25,162 for 24 months beginning June 25, 1982.

The process of normalizing a data base schema involves optimizing both the representation of information and the ease of updating the data base. Normalization is the process of taking a schema and transferring it to another schema which is free of representation problems or anomalies. This process of normalization suffers from the lack of a general theory. The project is therefore aimed at the development of such a theory and is seeking general concepts of normality which are applicable to all relational data base schema. These concepts will lead toward the development of specific normalization procedures applicable to a large class of schemata.

This project was originally funded as NSF Grant IST81-16333 to the University of Virginia, and was transferred to the University of Vermont when the investigator accepted a faculty position there.

#104

Representing Semantic Information Within Databases. *State University of New York*, Department of Computer Science, Stony Brook, NY 11794. D. S. Warren. $183,755 for 24 months beginning April 30, 1981.

To employ the information in a database effectively, a person or an application program needs certain auxiliary descriptive information, concerning the format and meaning of the data and also about the relationships among different kinds of data. This information describes the portion of the real world that the database models, and specifies the system or representation, that is, how the real world entities are encoded. It is proposed to study how such information can be incorporated into the database itself. The investigation will be pursued within the framework of the relational database model.

The first phase of the work, already underway, is the identification and classification of the kinds of descriptive information that are both useful and commonly available. On the basis of the results of this work, a data semantics language (DSL) will be formulated which will make it possible to state the relevant descriptive information in formal terms. Methods will then be investigated for translating the DSL into a relational format. The DSL and its format should be compatible with a variety of applications programs, such as a database tutor, a query handler, a database integrity checker, etc. To foster such compatibility, pilot versions of such programs will be developed.

#105

Research into the Structure, Accessing, and Manipulation of Numeric Databases: Phase I. *King Research*, Rockville, MD 20852. D. M. Liston. $29,970 for 6 months beginning September 25, 1981.

The general problem addressed by this research is the design of systems to facilitate the management and use of numeric data resources. Special emphasis is placed on assisting analysts who have data in hand to gain the kinds of intelligence about those data needed to draw solid conclusions from them. The research will seek to test, refine, and extend an emerging body of theory regarding the use of faceted classification to represent the nature of data elements and data instruments. This theory will be applied in Phase I to the design of two distinct systems: a data system which gathers, stores, operates on, and provides access to numerical data; and a "metadata" system which classifies, indexes, stores, and provides access to information about those data. Phase II will involve the experimental implementation of these systems for the purpose of evaluating the theory and design methodology applied in Phase I.

#106

Research on Adaptive Knowledge Acquisition Systems. *University of Michigan*, Ann Arbor, MI 48109. J. H. Holland. $118,437 for 24 months beginning December 30, 1980.

A set of knowledge-acquisition principles, developed in previous theoretical research, will undergo feasibility testing, using a flexible working model. The class of systems defined by the principles under study is intended to be both broadly applicable (to many domains of knowledge) and flexible in its operation. The breadth is achieved by couching the learning principles abstractly, without reference to particular domains. The flexibility arises because the user need only supply the system with a succession of ratings of its performance in order for the system to adapt to that user's needs; it is the system that must generate an attempted adjustment.

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The learning algorithm will manipulate a complex semantic network involving both associations and declarative statements. The algorithm produces new classifications by recombining parts of high-level classifications ("top-down" learning) and by generalizing attributes assigned to inputs ("bottom-up" learning). Because the elements of the network are actually represented as productions, the learning algorithm can modify network processing and associations by modifying the messages sent and received by the productions. Both new classifications and modified messages are treated as conjectures to be tested against user ratings.

#107

Research on Computer-Based Systems for Problem Structuring. *University of California*, Department of Computer Science, Los Angeles, CA 90024. J. Pearl. $77,806 for 12 months beginning November 5, 1981.

The goal of this research is knowledge which will enable the design of information systems to assist human problem solvers. The investigator has implemented an experimental prototype which demonstrates the feasibility of domain-independent structuring assistance through an English-like dialog. That system will be expanded to include capabilities for a more flexible and congenial dialog with the user: (i) adaptive paraphrasing of its own queries, (ii) acceptance of free-language inputs at the user's initiative, (iii) acceptance of free-style linguistic quantifiers, and (iv) an augmented ability to answer queries by the user. Capabilities will also be implemented to make the interaction more efficient: (v) a conversational inference module specializing in the explication of causal networks, (vi) acceptance of numerically expressed relationships, and (vii) a case-driven dialog to explicate the semantic link between pre-stored structure and a case-specific description.

#108

Research on Human Information Processing of Visual Displays. *University of Nebraska*, Psychology Department, Lincoln, NE 68588. J. H. Flowers. $60,429 for 24 months beginning July 24, 1981.

This research concerns the ability of human observers to allocate attention to spatial regions of a visual display, and their ability to ignore irrelevant visual information which appears in the vicinity of their attentional focus. One series of experiments examines how structural properties and familiarity in one portion of a brief visual display affect accuracy for recalling or recognizing material appearing in other regions of the display. A second sequence of experiments studies interference effects caused by distractors which appear in the spatial vicinity of a fixated target, and examines how the width of the attentional field can be influenced by a number of task variables which change the state of the observer. The resulting models of attention should provide clues for the design of artificial systems capable of selective abstracting of input information.

#109

Research on Information Aggregation and Value. *Indiana University*, Indianapolis, IN 46202. R. L. Winkler. $46,793 for 24 months beginning January 14, 1981.

The primary objective of the proposed research is the interpretation and efficient utilization of information from various sources. Information concerning an event or variable of interest is usually available from many sources, and a base inferences or decisions on all available information, it is necessary to combine the information from the different sources. One important, but often overlooked, feature of information from different sources is the possibility of stochastic dependence among the various pieces of information. For example, experts often have some common training and experience, they may see the same data and they may use similar aids (e.g., statistical procedures such as regression analysis). The proposed research involves the aggregation and value of information from dependent information sources. The ultimate aim of the aggregation procedures to be studied in the proposed research is to arrive at a probability distribution for any uncertain quantity of interest. This distribution, of course, should fully reflect all of the available information provided by the various information sources.

More specifically, the research will formulate information-aggregation models which allow formally for dependence among information sources; to study the value, or utility, of various combinations of information sources within the context of the information-aggregation models; and to investigate the optimal selection of information sources when observations from these sources are costly.

#110

Research on Natural Language Processing (Frame Selection). *Brown University*, Providence, RI 02912. E. Charniak. $131,920 for 24 months beginning January 26, 1981.

Language comprehension programs "understand" a line of text by relating it to a previously established stereotype called a "frame." A major problem is deciding which frames are relevant at a given point in a story. This problem will be investigated by writing a computer program which models the process. This program will store its knowledge in a complex data base which facilitates the retrieval of all frames which include events matching a single line of input. Since a sub-event may occur in more than one frame, there may be several such "candidate frames." More extensive tests are needed to select the best of these.

Since the information used in this process is the same as "common sense knowledge" used in general reasoning, the data base must also be reasonably efficient for such queries. A variation on a discrimination-net which types variables using the *isa* hierarchy, thus preventing false retrievals will be studied. The introduction of a new frame takes only constant time in such a data base, a useful feature since stories typically suggest many irrelevant frames. Problems involved in the deciding between candidate frames will be considered, and techniques developed in a work on systems for medical diagnosis and the understanding of computer programs will be examined for relevance to the project.

#111

Research on the Impact of a Computerized Circulation System on the Performance of a Large College Library. *Oberlin College*, Oberlin, OH 44074. V. B. Harris. $7,500 for 24 months beginning March 12, 1981.

The project is an in-depth study of the impact of an automated circulation system on the performance of a large college library. It will examine the relationships among three types of variables: (1) user attitudes, (2) system states (i.e., the operating status of the system), and (3) objective performance (i.e. the quality and quantify of the services rendered). Data collection will be integrated into the automated circulation system. Analysis and use of data will be integrated into regular library operations and management. One of the goals of the project is to develop and refine objective performance measurement mechanisms for library operations.

#112

Roubustness Properties of the Bibliometric Laws. *University of Chicago*, Graduate Library School, Chicago, IL 60637. A. Bookstein. $23,810 for 12 months beginning February 3, 1981.

For a period of almost a century, in a vast variety of fields, researchers have discovered surprising regularities when they count events or tabulate the sizes of things. The information sciences contain a number of these laws which will serve as the subject matter for this research. The challenge and importance of research in these laws is the recognition that many of them are identical in form, and that the different formulations are approximations of one another. Thus, though the content of these laws vary substantially, we may very well be considering differing manifestations of a single regularity which can be termed the bibliometric law.

The project will utilize a computer simulation technique to examine the resilience of these laws to ambiguities which results in their appearance as a consequence of a wide variety of underlying models.

#113

Signals of Product Quality. *Princeton University*, Department of Economics, Princeton, NJ 08540. C. Shapiro. $20,833 for 24 months beginning June 15, 1982.

This project examines the following two issues for markets in which buyers cannot observe the quality of the goods or services they are purchasing: (1) What incentives arise in competitive equilibria for sellers to supply quality in excess of the negligence standard? and (2) What sources of information, or signals are available in equilibrium for buyers to use to identify high quality sellers. Reputation, capital expenditures by sellers, prices, advertising levels, and market shares are studied as potential signals of product quality. The welfare properties of the different signals are determined. The implications for the appropriate scope of consumer protection activities are pursued.

#114

The Structure of Examples. *University of Massachusetts*, Department of Computer and Information Science, Amherst, MA 01003. E. L. Rissland. $147,848 for 24 months beginning January 14, 1981.

Examples are used to encode the information in complex ideas into cognitively manageable form in both scientific and ordinary discourse. Examples can serve several purposes, from introducing old ideas to new students to acting as a check on new theories. A formal theory of the representation and structure of examples, proposed here, would make computational applications possible and would contribute to an understanding of the transfer of scientific information. The proposed investigation deals with examples in four subject areas in which the use of examples tends to be particularly carefully structured.

This project has three objectives each dealing with a different aspect of examples: (1) analyze the structure and develop a conceptual and computational representation for examples; (2) produce taxonomies of examples based upon their functions in reasoning, learning and understanding; and (3) develop a model for the process by which one generates examples that meet prescribed specifications. Each objective will be pursued in each subject area. Finally, the findings will be generalized to an analysis of examples that is valid across the studied subject areas.

#115

Studies in the Organization of Information Structures. *University of California,* Engineering Systems Department, 405 Hilgard Avenue, Los Angeles, CA 90024. J. Pearl and N. Dalkey. $36,898 for 18 months beginning March 4, 1982.

This project is a theoretical analysis of procedures for reducing the amount of information required for making decisions, extending capabilities for the use of partial or incomplete information, and analyzing the role of judgmental information in decision making.

This effort is an extension of a project which developed a geometric representation for information systems and developed composition and decomposition procedures that allow the combining of information systems while minimizing the quantity of information.

This extension will continue the effort of examining information structures in a decision making environment. This work is being conducted as a formal analysis with the results forming general principles which may be used to derive specific applications such as the reduction or pruning of decision trees.

#116

Studies on Natural and Artificial Visual Categories. *Harvard University,* Cambridge, MA 02138. R. J. Herrnstein. $218,785 for 24 months beginning January 16, 1981.

The visual recognition of instances of naturally occurring categories of objects is an important information processing problem for animals and people. Powerful solutions to this problem are exhibited by biologically diverse organisms. Birds and primates have been found able to accurately recognize natural categories even those outside their own natural environment, e.g., pigeons have sorted among underwater photos for the presence or absence of fish.

The research is aimed at discovering more about the characteristics of natural and artificial categories. Animal and human subjects are tested with thousands of stimuli, including posed and unposed photographs of natural settings as well as artificially composed pictures. Among other goals, one is to understand why some categories, although difficult to define precisely, are easy to learn, whereas others, often easily defined, prove too difficult for individuals of a given species.

Also under study is the nature of any mathematical structure to the family of learnable categories for a particular species. The methodology will make it possible to consider such questions as whether learnability is preserved by the logical operators.

#117

Study of the Cost Function for Academic Libraries. *Tantalus, Inc.,* Cleveland, OH 44118. Kantor, P. B. $99,957 for 24 months beginning September 1, 1981.

This research will develop cost functions for the operations of academic libraries. The results of the research will include data on the unit costs of major information services provided by academic libraries.

Data will be collected from a stratified sample of approximately 100 academic libraries. Linear and non-linear models will be tested to determine which best describe the dependence of total costs upon services rendered, the relative unit costs of key services, and the impact on the cost function of such factors as automation, centralized processing and interlibrary loans.

#118

A Study of the Distribution, Processing and Use of Scientific and Technical Information in Research Organizations. *University of Wisconsin,* School of Business, Madison, WI 53706. G. P. Huber. $95,353 for 14 months beginning June 1, 1981.

This research is concerned with the distribution, processing, and use of information in organizations. There are three major objectives of the research:

- develop and test a set of models of information distribution, processing and use in organizations
- develop and test transferable procedures for mapping information flows in an organization, especially decision-related information flows, and
- develop and test transferable procedures for developing and testing diagnostic, predictive models of an organization's information system.

#119

Symposium on Conceptual Modelling: Perspective from Artificial Intelligence, Databases and Programming Languages: May 26-28, 1982, College Park, MD. *University of Maryland,* Department of Computer Science, College Park, MD 20742. M. L. Brodie. $40,339 for 12 months beginning February 2, 1982.

The primary objective of the symposium is to improve communications among information science researchers in Artificial Intelligence, Databases, and Programming Languages with respect to conceptual modelling of dynamic systems. The second objective is to identify similarities and differences in overlapping interests and to address how established and expected results in each area could be applied to open problems in the other areas.

A small number of active researchers will participate in the three-day symposium to investigate the topics in considerable detail. A presentationplus-debate format will encourage the desired interchange. Springer-Verlag will publish a book containing the presentations and edited discussions with introductory and summary sections by the principal investigator.

#120

Synthetic Holographic Computer Output. *Aerodyne Research, Inc.*, Bedford Research Park, Crosby Drive, Bedford, MA 01730. H. H. Caulfield. $29,945 for 6 months beginning September 15, 1982.

The objective of this research is to establish the feasibility of inexpensive, semi-real time, bright, easily viewed, three-dimensional holographic computer output. The proposed "holowriter" would draw three-dimensional images point by point under electronic control, just as two-dimensional images are drawn point by point on a CRT display. Holograms will be recorded on a thermoplastic medium, and various methods of point scanning will be investigated with a view to minimizing the time required. The investigators hope to maximize the holowriter's signal-to-noise ratio by using image-plane holography for localization and recording in the center of the scanned volume. If the project is successful, its results will be widely applicable in the design of advanced work stations.

#121

Systems Analysis of Scientific and Technical Communication in the United States. *King Research*, Rockville, MD 20852. D. W. King. $8,009 for 0 months beginning June 9, 1981.

The number of scientific and technical articles published doubles every eight to ten years. The range of possible uses for the information in those articles and the number of users are also increasing very rapidly. Therefore, the limits of what can be communicated by printing, mailing, storing, and retrieving pieces of paper may be at hand. On possibility for improving communication is to use computer systems to capture and transmit new information. This is not the only alternative, but it is one which holds great promise for the productive use of information. The objective of this project is to devise an analytic framework which will allow publishers and other information distributors to judge the potential of the electronic alternative to paper-based communication in relation to the conventional system. This framework is intended for use in comparing total communication systems in terms of costs, benefits, and other implications; in defining issues; and in specifying the data needed for the resolution of those issues.

This amendment to Contract NSF-C76-15515 provides for consideration of the impact of the revised copyright law on the analysis and on the cost model developed as part of the project.

#122

Technical Innovation in Established Cable Television Systems in Comparison with Developments in the State-of-the-Art. *Columbia University*, Graduate School of Business, New York, NY 10007. E. M. Noam. $9,978 for 9 months beginning June 10, 1982.

The purpose of the study is to investigate the rate of technical innovation in the U.S. cable industry. It decomposes this innovation into an "internal" or maturity effect of productivity gain due to a company's efforts in increasing productivity, and into an "external" or "vintage" effect of the technical progress in the state-of-the-art technology. Also considered are economies of scale. A comparison of the two rates of innovation permits an evaluation of the changes in the cable industry once the present phase of competition for cable franchises is completed. Subsidiary questions of research involve firm characteristics that affect internal innovation, such as size, horizontal and vertical integration, ownership-management, and local regulation. The research relies on extensive FCC data for all U.S. cable systems. The project has a basic component, dealing with innovation processes, and an applied component, in its analysis of the performance of a regulated industry.

#123

Tenth Annual Telecommunications Policy Research Conference. *Howard University*, School of Communications, Washington, DC 20059. O. H. Gandy, Jr. $17,000 for 14 months beginning August 7, 1981.

This award provides partial support for the Tenth Annual Telecommunications Policy Conference to be held April 25-28, 1982. The conference brings together researchers from universities, research institutes, public interest organizations and industry groups with government policy makers in an informal setting conducive to an open exchange of information and ideas. This exchange continues to be guided by current research on the prospects and problems occasioned by changes in information and telecommunications systems and markets.

This past year has been characterized by increased competition in domestic and international markets for information and telecommunication systems and services. New ventures, technical advances and the relaxation of regulatory constraints have generated considerable excitement and uncertainty about the impact of these changes on existing services and social systems. This year's conference addresses the issues raised by this trend, with a special emphasis on the changing international environment. In addition, a special effort is made to examine the impact these changes will have on traditional service providers in education, health and the postal service.

#124

Text Constructed from Informational Units. *Columbia University*, Center for the Social Sciences, 420 West 118th Street, New York, NY 10007. C. D. Parsons. $265,986 for 20 months beginning December 11, 1981.

The objective of this project is to develop a method of analyzing information. The method is both a theory of information and a procedure for dealing with the information in sources such as scientific articles.

A previous project showed that elementary "units" of information exist and developed a method for getting these "units" out of information carrying material. The current project is seeking to discover how independent presentations of information, such as entire articles, may be composed out of these informational units. The research will provide the theoretical basis for understanding how information items such as journal articles are structured from the basic "units" and other material. In addition the knowledge will indicate ways in which information in articles can be automatically processed.

#125

Theoretical Basis for the Development of Document Preparation Systems. *Stanford University*, Department of Computer Science, Stanford, CA 94305. D. E. Knuth. $153,961 for 12 months beginning June 3, 1982.

This project is a continuation of ongoing research into scientific problems associated with the generation, representation, and display of the textual and graphical information that constitutes a "document." Among these problems are (a) the development of tools for improved communication of the ideas behind how complex computer programs work; (b) the development of interactive versions of tools which have proved effective when used "off-line;" and (c) the development of better methods for integrating illustrations with text. Such problems had been thought to have little connection with formal scientific methods. The investigators' work to date has shown, however, that the introduction of mathematical techniques can be extremely effective.

#126

Theoretical Foundations of Natural Language Processing. *Yale University*, Department of Computer Science, New Haven, CT 06520. R. C. Schank. $16,215 for 0 months beginning January 26, 1981.

The objective of this research is to determine whether the fundamental constructs of human knowledge representation are invariant across languages. There are many practical implications which would derive from this finding; one of the most obvious being in the area of knowledge-based automatic text translation. Unlike previous attempts at machine translation, which involved elaborate transformations of syntactic structures between each pair of languages, text understanding systems could be developed based upon an intermediary, language-free, meaning representation. The focus of this work will be transformations from natural language forms to conceptual structures and back to natural language. The use of more than one language will allow a check on the important issue of the extent to which the meaning representations are language-independent.

The work will utilize two different computational understanding systems, one of them already well-developed, the other to be further refined. Use of the two systems will make it possible to investigate two very different aspects of the understanding and generation processes. One of the systems is capable of re-expressing complex descriptions of events, because it can represent and manipulate sophisticated aspects of human interaction. The other system has a much more detailed database of domain-specific knowledge. Both of these aspects must be well-developed in order to achieve an adequate language-independent meaning representation.

#127

Theoretical Investigation of Database Constraints and Semantic Constructs. *University of Southern California*, Department of Computer Science, Los Angeles, CA 90007. R. B. Hull. $28,949 for 24 months beginning June 18, 1981.

Theoretical investigation has made substantial contributions to the field of databases in the past decade. Much of this work has been based on the relational model, and centered around semantically motivated constraints such as functional dependency. Recently, the notion of all instances (or relations) satisfying a given set of constraints has arisen in a variety of contexts, and has yielded important new results concerning constraints in the relational model.

It is widely accepted that the relational model is not capable of representing many naturally occurring application environments in a clean, semantically suggested manner. Several semantically motivated data representation constructs have been proposed to fill this void. However, there has been little theoretical investigation of these constructs. Recently, the PI has developed a theoretical model for the study of these and related notions. Although this work is in its preliminary stages, some interesting results have been obtained.

This research extends the work described above, both in the relational model and in the area of semantic data modelling. The investigation is mathematical in nature, using primarily set-theoretic and algebraic tools, and is potentially applicable to a variety of database management issues.

#128

Theory and Computation for Natural-Language Question-Answering. *Stanford University*, Department of Computer Science, Stanford, CA 94305. S. J. Kaplan. $50,209 for 24 months beginning March 16, 1981.

The proposed research is aimed at identifying principles of usefulness in responding to natural language questions and developing computational techniques for applying these principles in automated question-answering systems. Previous research has demonstrated that simply giving direct, correct answers to questions does not provide adequately informative or appropriate responses. Consequently, there is a need for techniques that indicate when various types of direct and indirect responses are appropriate, and what those responses should be. Emphasis will be on developing a partial taxonomy of response types, and the associated theory for their application in natural language query systems. The availability of computational techniques for providing cooperative responses to questions should substantially improve the usefulness and responsiveness of existing and future information systems.

#129

A Theory of Approximate Reasoning. *University of California*, Electronic Research Laboratory, Berkeley, CA 94720. L. A. Zadeh. $31,500 for 12 months beginning August 25, 1981.

Professor Zadeh has been investigating data base semantics under grant MCS-7906543. His results generalize both truth-conditional and possible-world semantics. Additionally he has obtained results about the cardinality of fuzzy sets and fuzzy probabilities. Progress has been good.

#130

Toward Automated Natural Language Processing: Phrase Linking Grammars for Syntax and Semantics. *University of Washington*, Department of Computer Science, Seattle, WA 98125. R. W. Ritchie. $101,184 for 12 months beginning April 30, 1982.

This research project is focused on the characterization and understanding of natural language. An information structure called the "linked tree" is being used as a representation which will allow a syntactic and a semantic interpretation of natural language as well as the process of understanding natural language.

The investigators are particularly interested in the development of a restricted syntactic theory that is adequate to allow a revealing description of any natural language; an integration of semantics with syntax; a formulation of a theory of parsing and interpretation that is consistent with available psycholinguistic evidence; and insight into the exploitation of parallelism to study the complexity of language.

#131

Understanding Natural Language Scene and Event Descriptions: Cognitive Universals and Computer Programs Based on Combined AI and Linguistics Methodologies. *University of Illinois*, Coordinated Science Laboratory, Champaign, IL 61820. D. L. Waltz. $267,407 for 36 months beginning October 23, 1981.

The central goals of this project are: (1) to develop computer programs which can represent the possible meanings of English language scene and event descriptions, and select the most appropriate meanings; and (2) to develop a systematic body of knowledge about the connections between perceptual schemes and linguistic descriptions of the perceptual world.

These goals are to be pursued by methods from linguistics and artificial intelligence. One line of work consists of detailed analyses of the scene and event description mechanisms for several non-Indo-European languages as well as for English. The results of this analysis will be used both to construct systems of primitives for meaning representation, and to refine and extend existing computer programs for representing and reasoning about English scene and event descriptions. The programs will in turn test the generality of the linguistic analysis. This research aims to advance the state of knowledge about cognitive universals underlying language, and to take scientifically sound steps toward systems which can learn through perceptual experience, as well as toward systems which can model in detail and understanding of metaphors and analogies between the abstract and sensory/motor worlds.

#132

The Use of Teleconferencing in Administrative Hearings. *University of New Mexico*, Albuquerque, NM 87131. J. R. Corsi. $31,971 for 4 months beginning April 30, 1981.

This project will produce a refined research design to test the cost effectiveness and measure the effects on due process of teleconferencing in administrative hearings. Additionally, extensive baseline data will be collected on the existing fair hearing process in New Mexico. The project consists of the following major tasks: (1) collecting of baseline data through archival examination of Aid to

Families with Dependent Children (AFDC) and Employment Security Commission (ESC) hearing files, observation of the on-going hearing process, and a client survey; (2) completing cooperative agreements with the New Mexico Employment Security Commission and the New Mexico Health and Social Services Department to facilitate the collection of baseline data and establishing required protocols for the experiment planned for the second phase of the project; (3) selecting specific variables, developing the measurement instruments and constructing appropriate models to test refined research hypotheses prior to the experimental phase; (4) considering in detail alternative experimental or quasi-experimental designs with an analysis of the benefits and costs of using each design; (5) conducting a small-scale pilot study to pre-test the experimental design and aid in detecting unanticipated problems both with the design and the protocol established to handle the assignment or reassignment of subjects to experimental conditions.

#133

Value Added Processes in the Information Life Cycle. *Syracuse University*, School of Information Studies, Syracuse, NY 13210. R. S. Taylor. $166,612 for 18 months beginning June 16, 1981.

This research is aimed at developing a methodology for the analysis of value added processes in the information life cycle. Three major areas will be examined: the value added stages of information processing systems, the system costs for these stages and the costs and benefits to users of the various data bases. The researchers will utilize data/information from abstracting and indexing services as they are well established and understoood information services. Research such as this is particularly important today as the quantity of information has increased, at the same time that costs for handling/processing information have increased thus making the need to generate more income imperative.

#134

Verbs in Databases. *Boston University*, Department of Mathematics, 881 Commonwealth Avenue, Boston, MA 02215. S. C. Salveter. $129,980 for 24 months beginning September 17, 1982.

A number of advances have recently been made in support of querying a data base using natural language. However, little effort has been expended on natural language data base update. Natural language quering allows one to relate nouns and stative verbs to objects in the database and this is often sufficient to interpret queries. Update seems to require counterparts in the database for active verbs, such as "hire," in addition to what is required by the querying process.

This project is exploring the use of "verbgraphs" as a representation for active verbs. A verbgraph is a structure for representing the various database changes corresponding to the actions that a verb describes. This structure may be used to select among the variants in processing a natural language update. The project is formalizing the specification of verbgraphs, use of verbgraphs in an update system with limited syntax, and the computer-assisted design of verbgraphs.

#135

Voice Interactive Computer Systems. *Duke University*, Department of Psychology, Durham, NC 27710. A. W. Biermann. $108,041 for 12 months beginning December 14, 1981.

The investigators will study the dynamics of human-machine voice interactive problem solving with the goal of constructing fast and efficient voice interactive computer systems. The approach to establishing human-machine voice communication will include discovering both how to train potential users to limit their speech to a reasonable subset of English and how to stretch the technologies of voice and language processing to cover that subset. Studies will be made of human speech behavior in problem solving situations and a voice interactive computer system will be constructed to process it.

The proposed voice interactive system will allow the user to display data on a computer terminal and manipulate it using voice commands and touch sensitive inputs to the screen. Each command will result in immediate action visible on the screen allowing the user to confirm that a proper response has occurred. If an error is observed, the user may request a "back-up" and then rephrase the command in more careful terms. System prompts and error messages will be returned by synthesized voice and the total system design will be styled for fast, convenient interactive behavior. This system will be an extension of the NCL natural language programming system which has been built and tested over the last several years.

This project is collaborative research with Dr. Robert Rodman of North Carolina State University.

#136

Voice Interactive Computer Systems. *North Carolina State University*, Department of Computer Science, Raleigh, NC 27650. R. D. Rodman. $33,243 for 12 months beginning December 14, 1981.

The investigators will study the dynamics of human-machine voice interactive problem solving with the goal of constructing fast and efficient voice interactive computer systems. The approach to establishing human-machine voice communication will include discovering both how to train potential users to limit their speech to a reasonable subset of English and how to stretch the technologies of voice and language processing to cover that subset. Studies will be made of human speech behavior in problem solving situations and a voice interactive computer system will be constructed to process it.

The proposed voice interactive system will allow the user to display data on a computer terminal and manipulate it using voice commands and touch sensitive inputs to the screen. Each command will result in immediate action visible on the screen allowing the user to confirm that a proper response has occurred. If an error is observed, the user may request a "back-up" and then rephrase the command in more careful terms. System prompts and error messages will be returned by synthesized voice and the total system design will be styled for fast, convenient interactive behavior. This system will be an extension of the NLC natural language programming system which has been built and tested over the last several years.

This project is collaborative research with Dr. Allan Biermann of Duke University.

#137

Workshop on Logic Programming for Intelligent Systems. *Logicon, Inc.*, Woodland Hills, CA 91364. C. A. Montgomery. $34,729 for 5 months beginning July 21, 1981.

The project consists of a workshop to consider the role of logic programming languages in problems of representation and in intelligent systems. Particular attention is paid to Prolog, a language which many of its users consider easier and more economical to use than versions of LISP. Prolog takes an initial database of relations and operates on these, seeking a proof of a goal relation. It has been applied to various areas including natural language text analysis and access to relational databases. Much of the world's use of logic programming has taken place in Europe and an important feature of the workshop is the interaction of European Prolog experts with U.S. experts in LISP.

#138

A Workshop on Measurement of Communications and Information Science, Summer of 1982, Cambridge, MA. *Massachusetts Institute of Technology*, Center for International Studies, E38-642, Cambridge, MA 02139. I. D. Pool. $29,326 for 3 months beginning May 23, 1982.

Methods for the quantitative and qualitative measurement of information and communication (information flow) have evolved differently in various scientific fields. This award is for a workshop on the theoretical basis for concepts of information activity and flow measurements and indicators for social and economic analysis. The goal is to improve measurement techniques and to identify theoretical correspondences useful for economic, behavioral and social research on information activities processes and impacts.

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